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# CONGENITAL ABSENCE OF THE SEPTUM PELLUCIDUM*

## ITS DIAGNOSIS BY ENCEPHALOGRAPHY

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ABSENCE of the septum pellucidum without other abnormalities of the brain is a rare condition. Only 3 cases have been reported in the literature, all of which occurred as incidental findings at necropsy. In a series of 2,500 encephalograms done at the Neurological Institute, only a single instance of this condition was encountered.

The diagnosis has never been made clinically. By means of encephalography, however, the absence of the septum pellucidum can be recognized. The object of this paper is to present a case in which the encephalographic appearance was so definite that the diagnosis of congenital absence of the septum pellucidum could be made.

### LITERATURE

A considerable number of case reports of perforation of the septum pellucidum appear in the literature. With the exception of 3, however, all were associated with internal hydrocephalus due to various causes. A number of other cases of absence of, or defects in, the septum pellucidum were recorded as congenital anomalies, but these were associated with defects in the corpus callosum and other variations in the brain.

Hochstetter[2] in 1924 described the brain from an adult in which the septum pellucidum was lacking and in which there was no hydrocephalus or anomaly of the corpus callosum. No clinical description was given. This author also described the brains of 2 human fetuses measuring 118 mm. and 168 mm. respectively, each of which showed an absence of the septum pellucidum but one of these had internal hydrocephalus.

Hahn and Kuhlenbeck[1] in 1930 reported a case of pineal tumor with secondary internal hydrocephalus with perforation of the septum pellucidum which was revealed at post-mortem examination. They had made ventriculograms (encephalograms—sic) in this case and reproduced only a lateral view which in retrospect supposedly showed several small perforations of the septum pellucidum. They also gave brief descriptions of 3 human brains of unknown origin, 2 of which showed internal hydrocephalus with perforations of the septum pellucidum. The third brain had a normal ventricular system and a normal corpus callosum but lacked entirely a septum pellucidum.

This last specimen of Hahn and Kuhlenbeck and the adult brain described by Hochstetter are the only cases we have been able to find in the literature where there was an absence of the septum pel-

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Fig. 1. Case 1. X-Ray No. 25996. Anteroposterior horizontal encephalogram showing normal-sized lateral ventricles which are confluent due to the absence of the septum pellucidum. Note the increased ventrodorsal measurement from the thalamus to the corpus callosum and the ventral projection of air contiguous to the dorsal surface of the fornices.

lucidum, probably congenital, without associated abnormalities. To these 2 cases may be added the one fetal brain also reported by Hochstetter in which no hydrocephalus existed.

## CASE REPORT

Case 1. A. G.* (N. I. No. 17324), a white female, aged twenty-three, admitted September 18, 1933. Encephalographic diagnosis: congenital absence of the septum pellucidum.

*Complaint.* Disturbances in personality.

*Family and Past History.* The mother died of carcinoma of the breast in the fifth decade. The father and a younger sister were living and well at the time of the patient's admission to the hospital.

At the age of two the patient had a fall from a chair from which she recovered in two days.

*Present Illness.* In December, 1919, she became seriously ill with delirium, confusion, speech disturbances and diplopia. A lumbar puncture was done and a diagnosis of epidemic encephalitis was made at that time. The illness lasted until April, 1920. Since this illness the patient has been a difficult person to manage, troublesome to her teachers and her family. She was sexually hyperexcitable and tended to make crude sexual advances on short acquaintanceship. She showed periods of intense melancholy and bursts of anger on slight provocation.

*Physical and Neurological Examination.* The patient was a tall, slender, prognathous young woman. Her general physical examination was entirely negative. She showed normal coordination. The deep reflexes were slightly hyperactive but equal. No abnormal reflexes were present. The speech was somewhat thick but otherwise not abnormal. The sensory system and cranial nerves were intact.

*Laboratory Examination.* Routine tests on the blood and urine were negative. The spinal fluid contained three cells per cubic millimeter; the test for globulin was negative; the total protein was 24 mg. per 100 c.c. The colloidal gold curve was 1110000000. The spinal fluid Wassermann reaction was negative.

*Encephalography*, September 19, 1933. Encephalograms after the injection of 50 c.c. of air, showed the lateral ventricles to be in their normal position and within normal limits in size. Their general configuration was normal. In the anteroposterior and posteroanterior views the two lateral ventricles appeared confluent medially (Figs. 1 and 2). The usual linear vertical shadow produced by the septum pellucidum was absent. At the midline ventrally

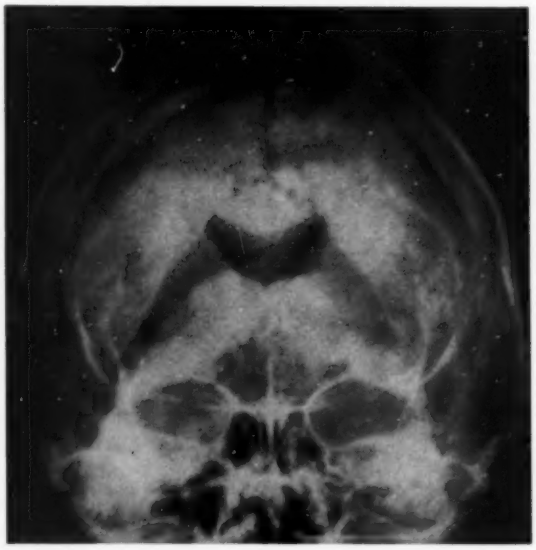

Fig. 2. Case 1. X-Ray No. 25996. Posteroanterior horizontal encephalogram showing the confluence of the lateral ventricles anteriorly and their normal separation posteriorly.

* We wish to thank Dr. Robert Bush McGraw for permission to report this case.

there was a nipple-like projection from the ventricles (see arrow Fig. 1). The dorsoventral measurement of the anterior two-thirds of the bodies of the lateral ventricles was increased. The third ventricle was in the midline and appeared normal in size and shape.

In the lateral views, with the patient in both the horizontal and vertical positions (Fig. 3), there was a comma-shaped shadow superimposed upon those of the anterior two-thirds of the bodies and the posterior half of the anterior horns of the lateral ventricles. This shadow had its convexity dorsally and the head of the comma anteriorly. It measured 4.9 cm. in the anteroposterior direction and 2.3 cm. at its widest part in the vertical plane. Stereoscopically, it represented the confluent portions of both lateral ventricles at the midline. The third ventricle, aqueduct and fourth ventricle appeared normal. The basal cisterns and cerebral sulci also showed no abnormalities.

*Impression.* Absence of the septum pellucidum without accompanying hydrocephalus, probably on a congenital basis.

## DISCUSSION

That absence of the septum pellucidum without other anomalies of the brain and without hydrocephalus may occur is adequately demonstrated by the descriptions of the 3 brain specimens with this condition, appearing in the literature. Its recognition by means of encephalography has been described in the present paper and was made possible by taking into account the following well-known facts.

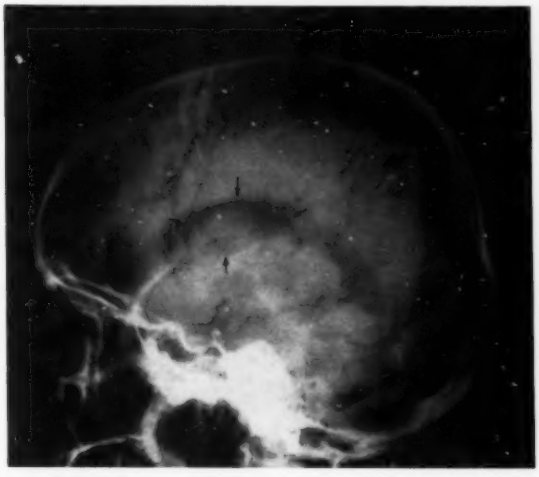

Fig. 3. Case 1. X-Ray No. 25996. Lateral horizontal encephalogram showing the comma-shaped shadow produced by the confluence of the two lateral ventricles due to the absence of the septum pellucidum.

Fig. 4. Case 1. X-Ray No. 25996. Lateral upright encephalogram showing the shadow of one air-filled ventricle (*A*); the darker superimposed shadows of the two lateral ventricles (*B*); and the still darker shadow of the confluent air in the two lateral ventricles (*C*) due to the absence of the septum pellucidum.

In cases in which a septum pellucidum is present, this structure forms in the encephalogram a well-demarcated vertical linear shadow interposed between the air shadows of the two lateral ventricles in the anteroposterior (Fig. 5) and posteroanterior views. This shadow is normally 2 to 3 mm. in width and at its ventral termination becomes widened symmetrically. This widened portion represents the anterior pillars of the fornix. In the case here presented the linear shadow was absent and a small nipple-like projection from the medial ventral portion of each lateral ventricle was seen on the dorsal surface of the anterior pillars of the fornix (see Figs. 1 and 2). In the lateral views, in cases with a normal septum pellucidum, there may be an intensification of the air shadows of the two lateral ventricles where these are superimposed. In Case 1, however, in addition to such an intensification, there was a third, still darker shadow (see Fig. 4) which represented the area where the two

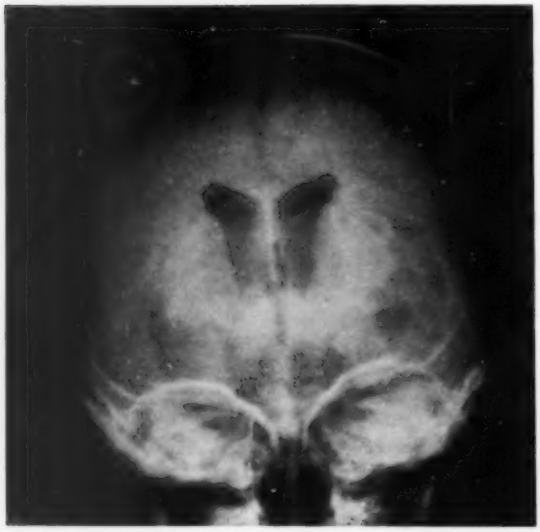

Fig. 5. X-Ray No. 24681. Anteroposterior encephalogram showing a normal septum pellucidum.

lateral ventricles were confluent. In other words, the darkest shadow was the result of the absence of the septum pellucidum with its 2 to 3 mm. of interposing tissue and the substitution for it of a column of 2 to 3 mm. of air.

Fig. 6. X-Ray No. 24705. Posteroanterior encephalogram showing a cavum septi pellucidi. Note the two leaflets of the septum pellucidum forming the lateral walls of the cavity.

Further confirmation of the views above expressed may be obtained from cases in which the encephalograms show the presence of a cavity of the septum pellucidum (Fig. 6). Here, the two attenuated leaflets of the septum pellucidum in the anteroposterior or posteroanterior views are plainly visible but are separated from each other by the width of the cavity. The lateral views of such a case (Fig. 7), however, cannot be distinguished from the lateral views of a case with an absence of the septum pellucidum, since a comma-

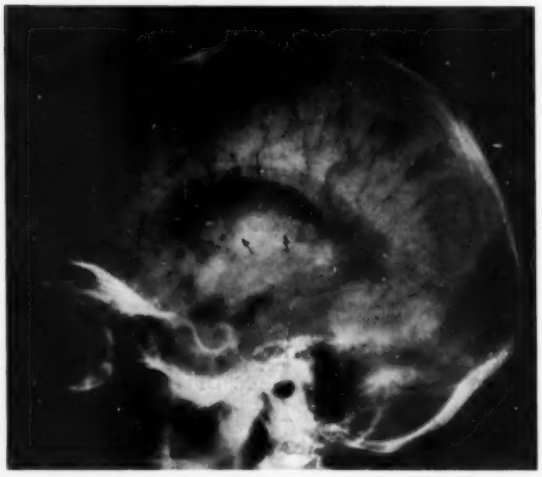

Fig. 7. X-Ray No. 24705. Lateral encephalogram from the same case as Figure 6 showing the air-filled cavity of the septum pellucidum.

shaped shadow is present in each, but in the one case it represents the air-filled cavity of the septum pellucidum and in the other, the defect produced by the absence of the septum pellucidum. The differentiation, therefore, of these two conditions can be made only in the anteroposterior and posteroanterior views.

Finally, in several cases of internal hydrocephalus due to obstruction of the foramen of Monro by tumors of the third ventricle, secondary perforations of the septum pellucidum of varying sizes were observed at operation in this clinic. In one such case the appearance at operation was described as follows: "On looking into the right lateral ventricle it was evident that the septum pellucidum was defective

throughout, and gazing through the opening made in the lateral wall of the right ventricle afforded a view of the left ventricle as well." The ventriculograms made before operation in this case were strikingly similar, except for the hydrocephalus, to the encephalograms of Case 1. In the anteroposterior and posteroanterior views (Figs. 8 and 9) the shadow of the septum pellucidum was absent. In the lateral view (Fig. 10) there was a markedly intensified shadow which represented the defect in the septum pellucidum.

Fig. 8. X-Ray No. 29830. Anteroposterior ventriculogram in a case of third ventricle tumor with hydrocephalus showing a confluence of the lateral ventricles due to a large defect in the septum pellucidum verified at operation.

Perforations of varying degrees in the septum pellucidum in association with hydrocephalus are quite common and are believed to be due to the ventrodorsal tension on, and the ultimate tearing of, this septum (Young[3]). In the case here presented the ventricular system was within normal limits in size. Therefore, this explanation cannot be used to account for the absence of the septum pellucidum in the present case.

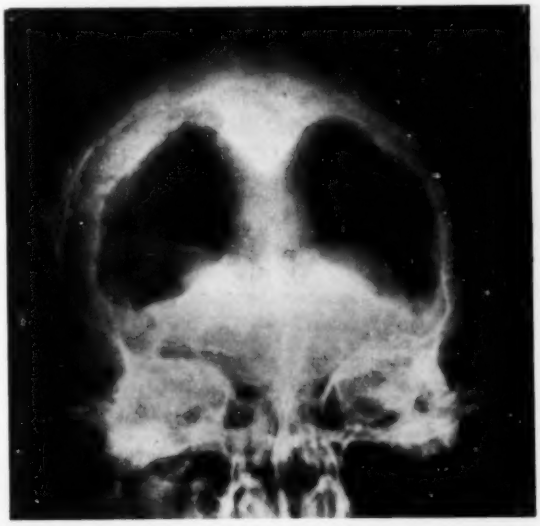

Fig. 9. Same case as Figure 8. Posterior ventriculogram showing the confluence of the lateral ventricles.

The history of trauma in this case, occurring at the age of two years, was probably of no significance as the recovery was prompt (two days) and the roentgenograms of the skull showed no sign of an old fracture. Moreover, the encephalograms revealed no evidence of porencephaly, cerebral atrophy or scarring.

It is hardly conceivable that the illness which was diagnosed as encephalitis was responsible for the absence of the septum pellucidum.

Practically the only other explanation

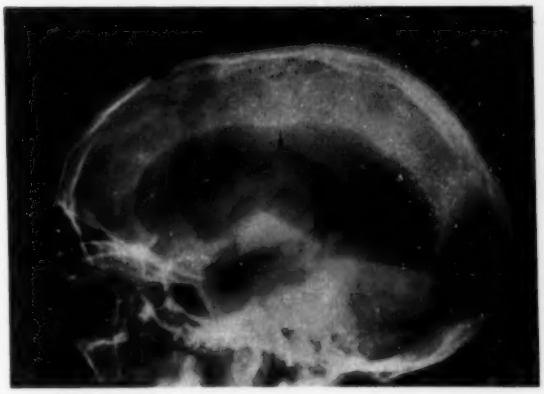

Fig. 10. Same case as Figures 8 and 9. Lateral ventriculogram showing the defect in the septum pellucidum which measures 8 cm. in length and 4 cm. in its greatest dorsoventral extent.

for the absence of the septum pellucidum would have to be on a congenital basis, to which category we believe this case belongs.

## SUMMARY AND CONCLUSIONS

A case is reported of a young woman with postencephalitic behavior disorders in whom encephalography disclosed a notable alteration from normal. In the anteroposterior views the shadows of the two lateral ventricles were confluent across the midline without evidence of an intervening septum. In the lateral views the region in which the two lateral ventricles are ordinarily superimposed was unusually intensified, again indicating an absence of the septum pellucidum. The ventricles were otherwise in their normal positions and within normal limits in size. A diagnosis was therefore made of absence of the septum pellucidum.

Except for an absence of hydrocephalus, the encephalograms in this case resembled those of cases with third ventricle tumor in which the destruction of the septum pellucidum (which had occurred as a result of the dilatation of the ventricular system) was verified at operation.

Since in the case here reported no hydrocephalus was present, the disappearance of the septum pellucidum was assumed to have occurred during fetal development.

## REFERENCES

1. HAHN, O., and KUHLENBECK, H. Defektbildungen des Septum pellucidum im Enzephalogramm. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1930, *41*, 737–742.
2. HOCHSTETTER, F. Quoted by Hahn and Kuhlenbeck, and Young.
3. YOUNG, A. W. The comparative anatomy of the septum pellucidum. *Psychiat. en Neurol. Bl., Amst.*, 1926, *30*, 203–234.

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# SERIAL BRONCHOGRAPHY IN THE DIAGNOSIS OF SUPPURATIVE PULMONARY PROCESSES*

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FOR THE last two years we have studied numerous cases of pulmonary abscess with our technique of serial bronchography under roentgenoscopic control, which allows us to study on a series of plates, taken at different intervals, the bronchial tree of the whole lung. The technique described in various papers is briefly as follows: After anesthetizing the pharynx, larynx and a nasal fossa, a rubber sound is introduced through the latter into the trachea. If unable to pass, it is put through the mouth with the help of a forceps. The patient is then placed on the roentgenoscopic table in the prone position, and turned on the side to be explored. The sound is then introduced into the main bronchus of this side under roentgenoscopic control and the iodized oil is injected also under roentgenoscopic control.

With our selector we take a series of plates at different intervals during the examination from the large bronchi to the pulmonary alveoli (Figs. 1 and 2).

The bronchial tree alterations, due to an abscess of the lung, may present different aspects according to the type and evolutive stage of the abscess.

In the acute stage, before the vomica, there are no shadows in the roentgenograms that would allow us to distinguish between an abscess from any other acute pneumopathy.

The destruction of the interalveolar septums has taken place but not the elimination; and, of course, there are no distinct shadows on the plates that can enable us to distinguish when a pneumonia or bronchopneumonia has turned to suppuration.

In this acute stage the bronchogram is normal due to the fact that the bronchial walls have not suffered the effects of the inflammatory process long enough to lose their elasticity and become dilated. In the alveoli, where there is a purulent exudate, the iodized oil will not penetrate and we cannot see the alveolar dispersion in the roentgenograms, thus giving the bronchial tree the image of a tree without leaves (Case 1).

FIG. 1. The patient with the sound passed through the nose into the trachea ready to be placed on the roentgenoscopic table. Our small selector may be seen attached to the fluoroscopic screen.

After the vomica, during the eliminating stage, the cavity appears and the surrounding pneumonic block decreases. The cavity, when observed in the roentgenograms, is irregular, multilocular, not well defined, generally full of pus and necrotic débris and hidden by the pneumonic process. Its bronchial communication is not sufficiently

* Read at the Thirty-fifth Annual Meeting, American Roentgen Ray Society, Pittsburgh, Pa. Sept. 25–28, 1934.

free and very often it is impossible to determine the hydroaerial level.

The bronchographic aspects during this stage are variable. As the bronchial communication of the cavity is not ample enough and the cavity itself is full, the iodized oil does not penetrate. This seems to be the general rule. If the acute cavity communicates with a large bronchus, it dilatation in the bronchus draining the cavity, the rest of the bronchial tree remaining normal. The cause of this dilatation must be referred to the infiltration of its walls by a strongly infected secretion (Case IV).

There exists a type of acute abscess in which the bronchial alteration runs parallel with the pulmonary changes, especially in the postoperative abscess. In this type we

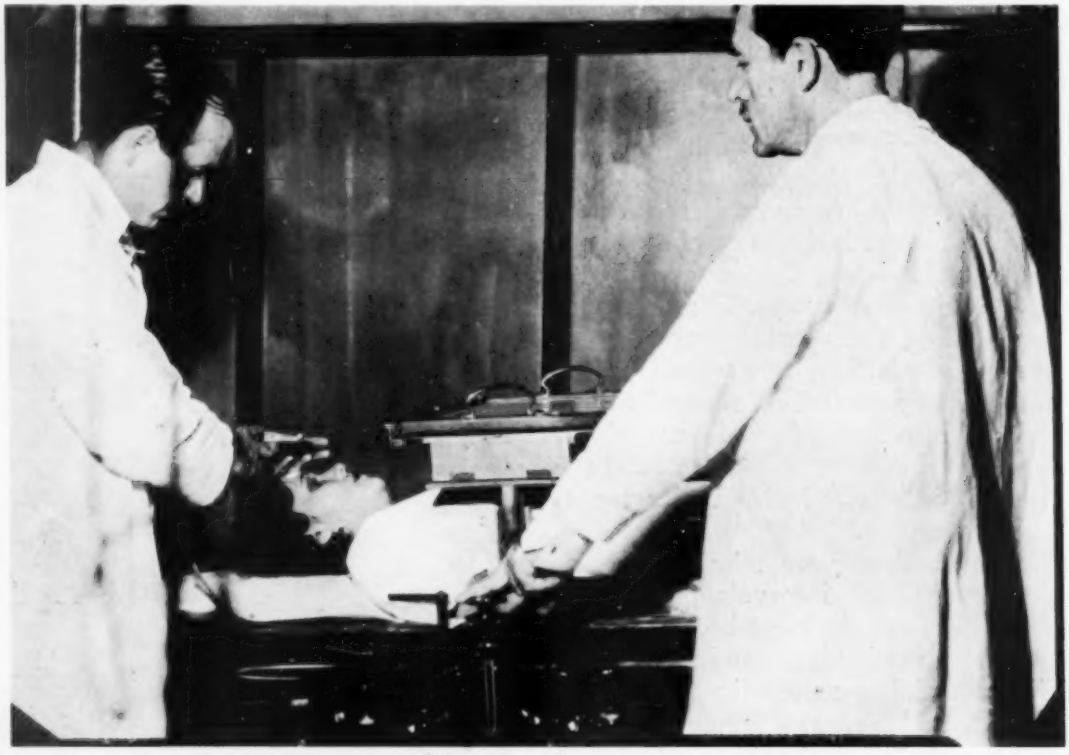


FIG. 2. The patient on the roentgenoscopic table with the sound in position. The assistant is ready to inject the iodized oil.

can be easily demonstrated in the roentgenograms (Case II).

The bronchial tree in this stage may still be absolutely normal, the bronchial wall resisting the inflammatory process that is confined to the mucosa. The opaque medium will not penetrate into the alveoli in the region of the abscess. Once the pneumonic process is resolved, the alveolar dispersion can be seen immediately, the bronchial tree then presenting the aspect of a tree with its leaves (Case III).

In some cases during this eliminating stage we may find a cylindrical or ampullar will find very early cylindrical dilatations of the bronchi of all the affected area. The dilated medium-sized bronchi are not followed by the small bronchi and the alveolar shadows, as in normal cases, the bronchogram having the aspect of a dead tree (Case V).

When a bronchopneumonic process turns to suppuration, it may present many small abscesses separated from each other but they may come together to form larger cavities (Case VI).

The roentgenological aspect of the chronic abscess is very characteristic. The

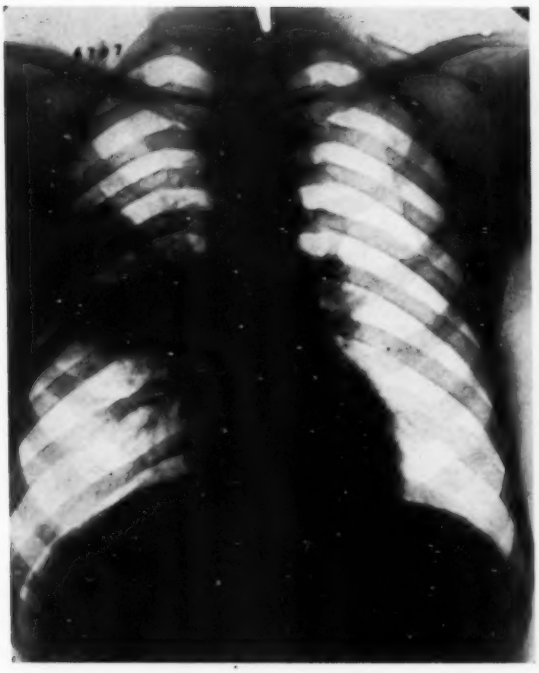


Fig. 3. Case I. M. L. G., aged twenty-five; service of Dr. Cárdenas. After fifteen days patient entered the service of Professor Cárdenas with cough, expectoration, high fever and pains in the right chest. Later presented abundant expectoration with bad odor and high fever. The roentgenogram shows dense area with a cavity at the middle lobe.

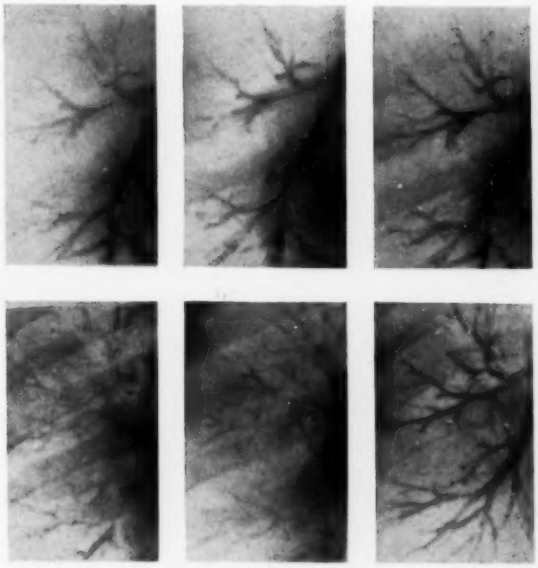


Fig. 4. Case I. The bronchogram shows no cavity, normal bronchial tree, but the iodized oil does not penetrate into the alveoli, giving the appearance of a tree without leaves.

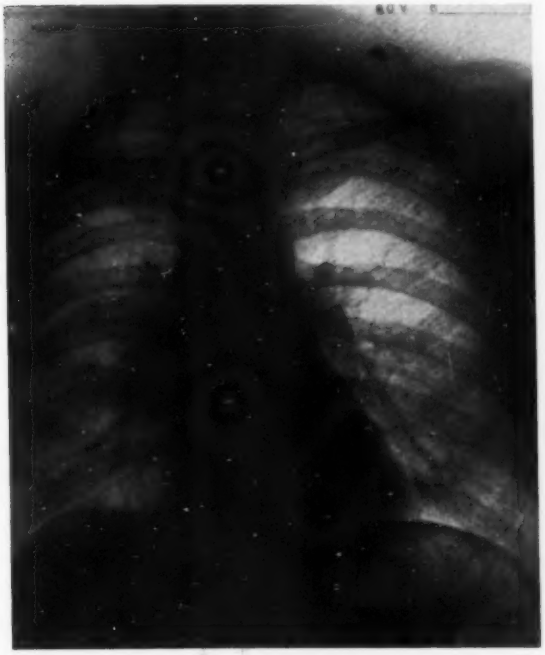


Fig. 5. Case II. A. P., patient of Dr. Romaguera. A month previously had cough, expectoration, sometimes bloody, high fever, pains in the right chest. The roentgenogram shows a dense area at the right hilus.

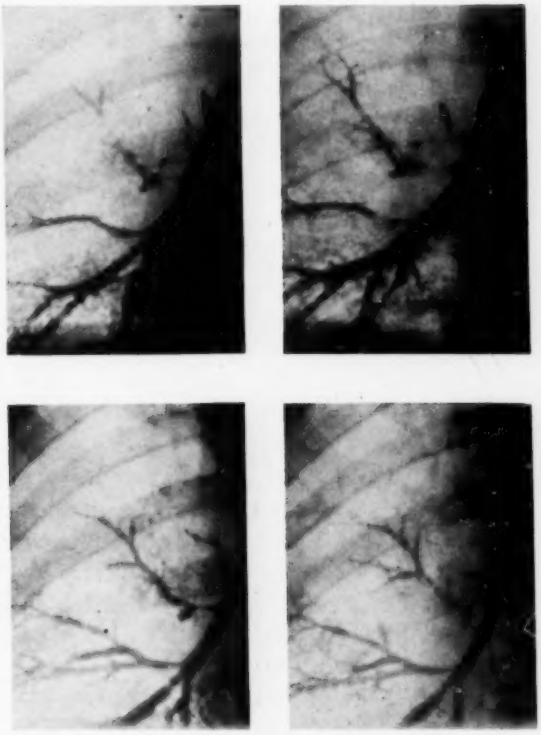


Fig. 6. Case II. The bronchogram shows small cavity at the entrance of the bronchus of the middle lobe.

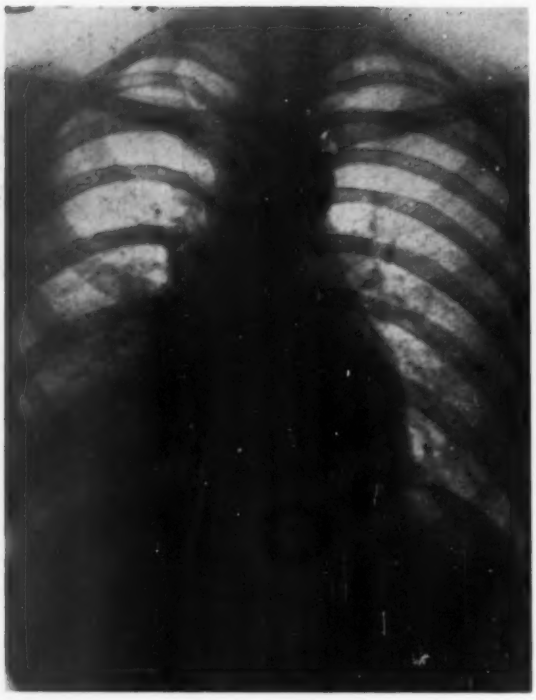


Fig. 7. Case III. A. M., after twelve days, with high temperature, presented a large vomica, followed by abundant expectoration and fever. The roentgenogram shows a dense area at the right base. The patient was discharged from the hospital after two weeks in normal condition and without shadows in the roentgenogram.

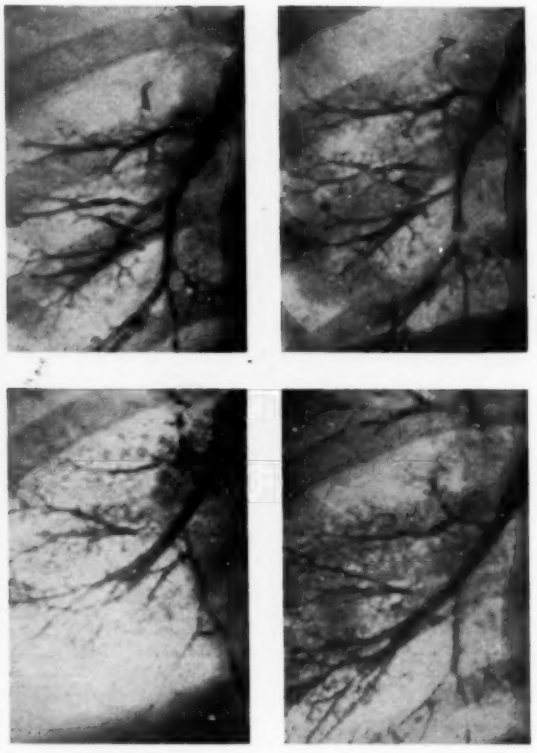


Fig. 8. Case III. The bronchogram shows a normal bronchial tree, the oil penetrating into the alveoli of the region occupied by the pneumonic process. The bronchogram has the aspect of a living tree.

cavity is generally regular and well defined, partially full and with ample bronchial communication. The hydroaerial level is almost always seen. Around the fibrotic wall of the cavity there is an extended zone of purulent alveolitis, crossed by fibrotic bands.

The iodized oil will nearly always fill the cavity. In some cases the stenosis of the bronchus draining the cavity will prevent its filling (Case VII).

We have observed in most of our cases a cylindrical or ampullar dilatation of the bronchus draining the cavity of the abscess. In some cases the draining bronchus may be normal, as well as the rest of the bronchi of the abscessed area, but we may see

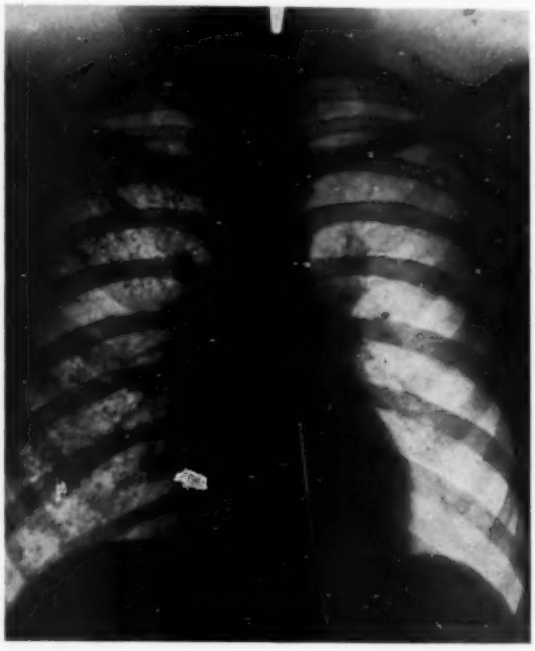
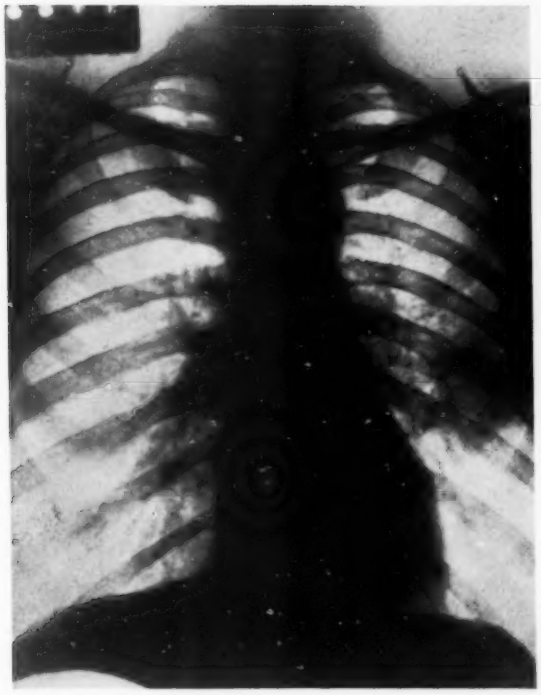


Fig. 9. Case III. After treatment. The roentgenogram shows remains of iodized oil but the pneumonic process is resolved.



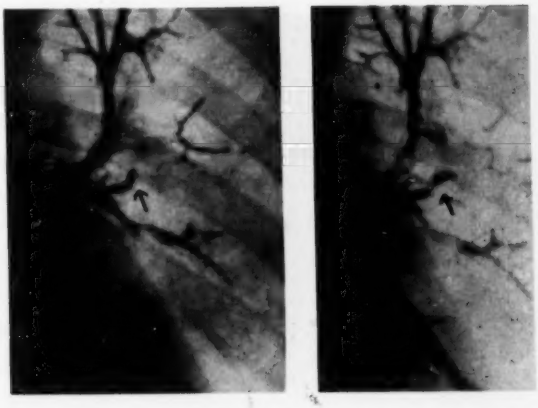


Fig. 11. Case iv. The bronchogram shows cylindrical dilatation of the bronchus draining the cavity.

Fig. 10. Case iv. M. S., aged forty-six; entered service of Professor Cárdenas on January 21, with high fever, cough, purulent expectoration, sometimes bloody. The roentgenogram shows a dense area at the lower portion of the upper left lobe with a cavity.

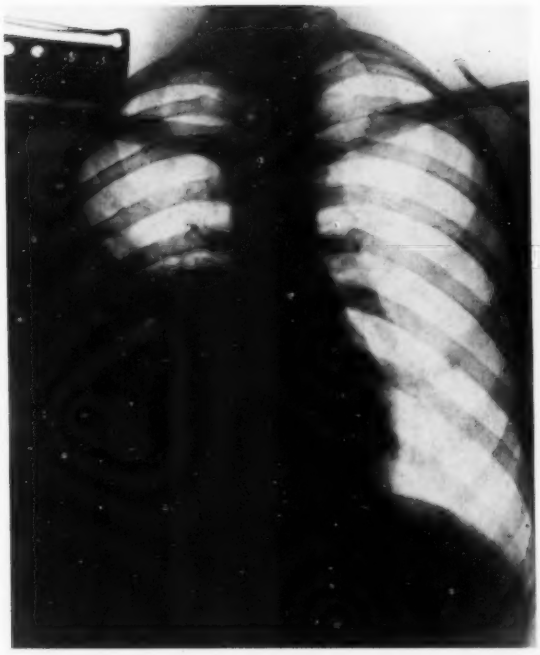


Fig. 12. Case v. B. G., aged forty-eight. Entered the hospital for an operation for chronic gastric ulcer. On April 18 a gastrectomy (Dr. Nuñez) was performed. Twelve days later presented cough and purulent expectoration. The roentgenogram shows a dense area at the right base.

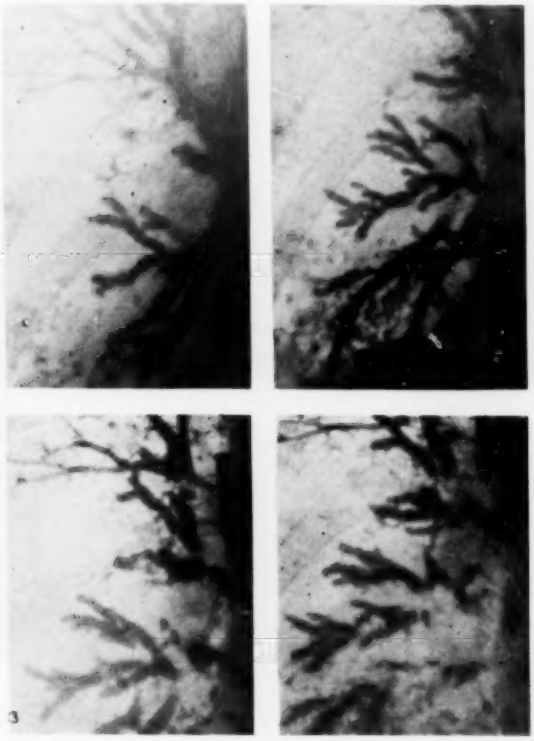


Fig. 13. Case v. The bronchogram shows a cylindrical dilatation of all the bronchi of the abscessed area having the appearance of a dead tree.

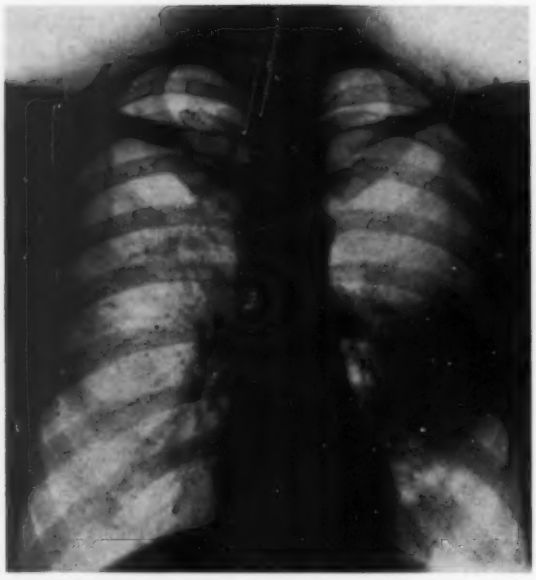


Fig. 14. Case vi. L. C. A month ago cough, expectoration and high fever. Clinical diagnosis, bronchopneumonia. The roentgenogram shows a dense area of the lower portion of the upper left lobe.

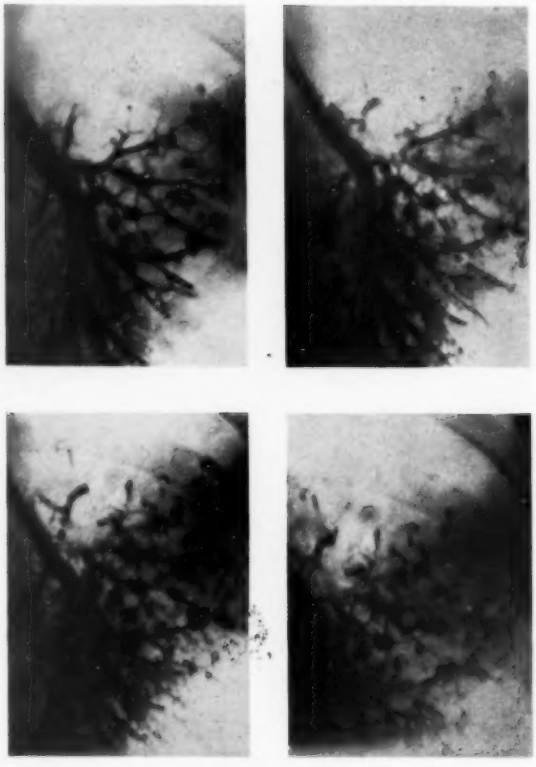


Fig. 15. Case vi. The bronchogram shows many small cavities in the region of the bronchopneumonic process.

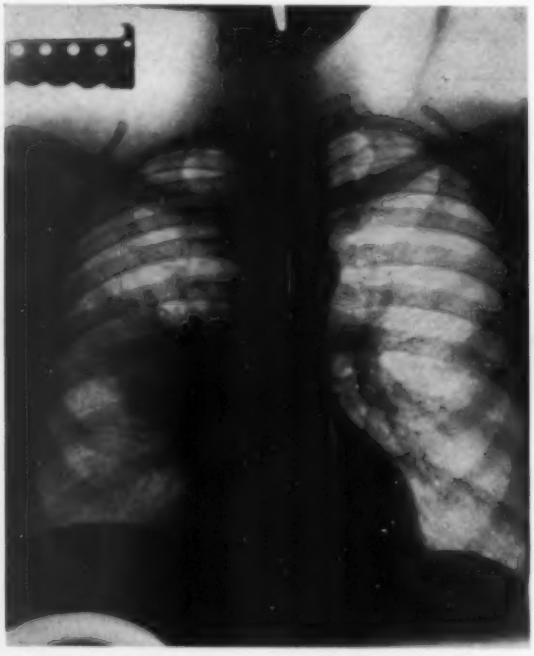


Fig. 16. Case vii. J. H. Three months ago began to have an acute pulmonary process with cough, expectoration and high fever. The roentgenogram taken two months later shows an ulcerated dense area in the right hilus.

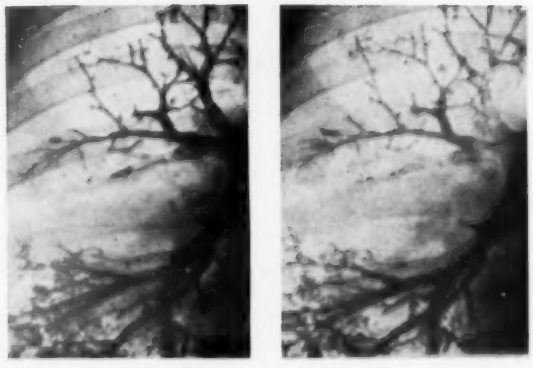


Fig. 17. Case vii. The bronchogram shows complete obstruction of the bronchus of the middle lobe.

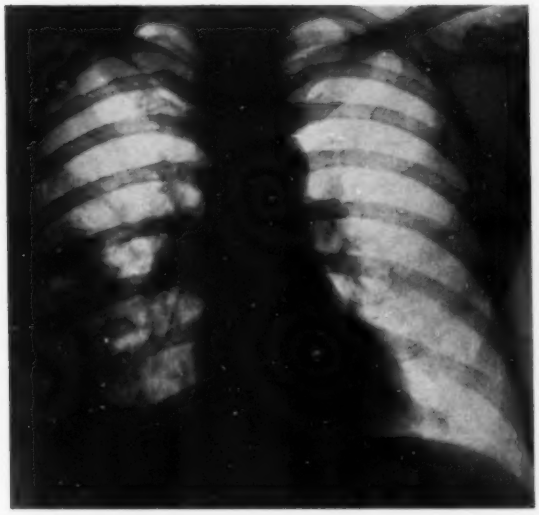


Fig. 18. Case VIII. R. G., aged fifty-two, entered the hospital with high fever, large amount of expectoration, with very bad odor. The roentgenogram shows an abscess of the axillary portion of the middle lobe.

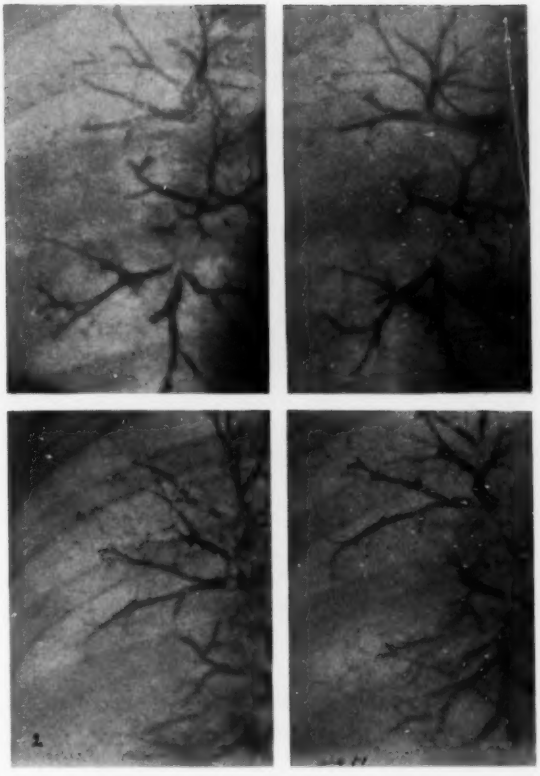


Fig. 19. Case VIII. The bronchogram shows an absolutely normal bronchial tree including the draining bronchus of the cavity but a cylindrical dilatation of a corresponding group of bronchi of the base.

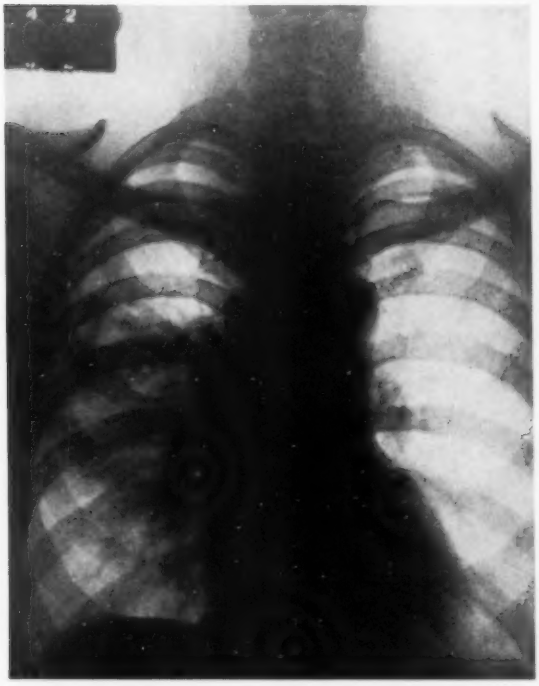


Fig. 20. Case IX. J. V., aged fifty, entered the service of Professor Antonetti. Had cough, fever and large amount of expectoration with bad odor and, at times, blood-tinged. The roentgenogram taken six months after the onset of the symptoms shows a large pneumonic zone of the middle lobe. The right base does not show any alterations.

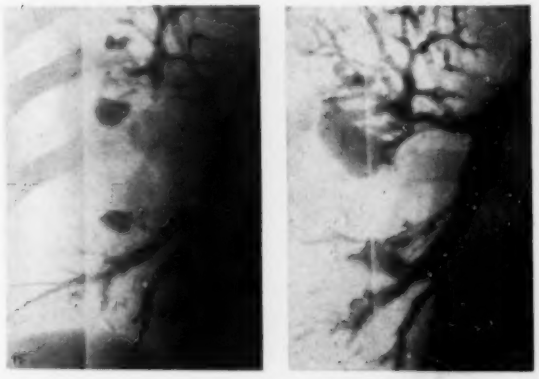


Fig. 21. Case IX. The bronchogram shows a large cavity in the center of the middle lobe. Cylindrical dilatations of the inside group of bronchi at the base, with a large sacciform cavity.

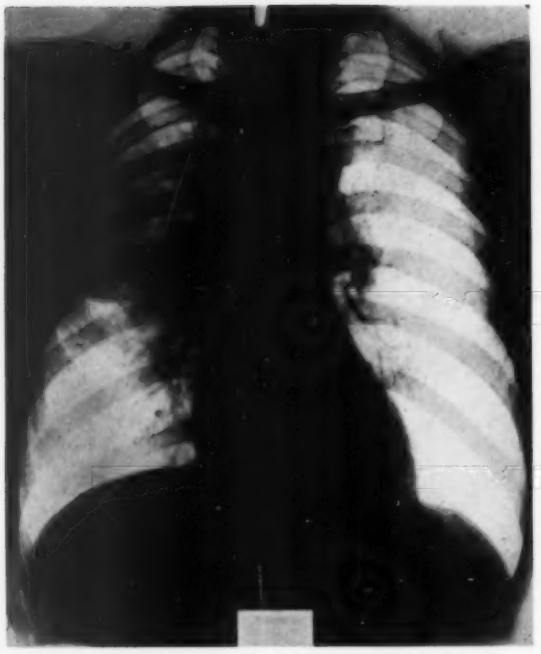


Fig. 22. Case x. J. R., aged fifty-five. Gastrectomy for gastric ulcer. A month later, high fever with purulent expectoration. The roentgenogram shows an excavated opacity of the upper right lobe.

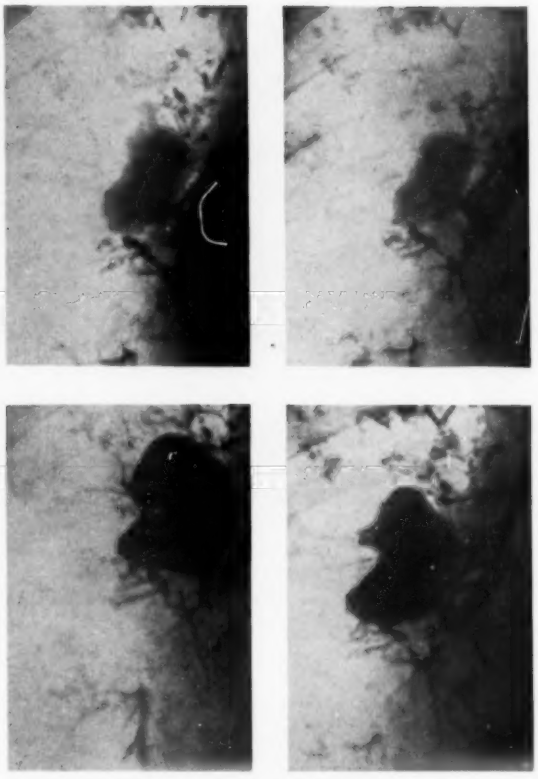


Fig. 23. Case x. The bronchogram shows a larger cavity of the upper lobe without cylindrical dilatation of the inner group of the bronchus at the base.

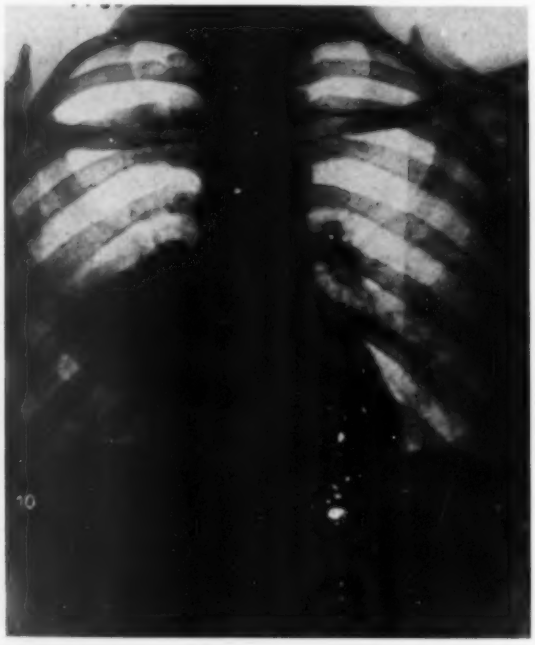


Fig. 24. Case xi. D. M. M., aged twenty-four, entered the service of Drs. Ortega and Cárdenas. Ten days after tonsillectomy patient started with cough, expectoration, fever and pain in the right side of the chest. One month later had bloody sputum and lately a large amount of expectoration with bad odor. The roentgenogram shows a dense pneumonic block without cavity visible at the inner portion of the middle lobe.

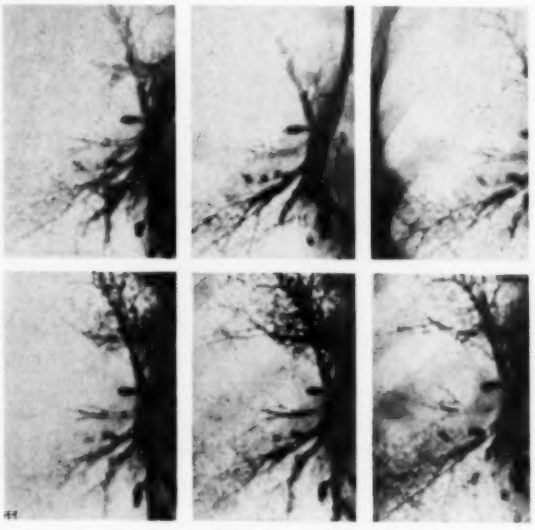


Fig. 25. Case xi. The bronchogram taken some days later. The cavity is visible. There is ampullar dilatation of the bronchus draining the cavity. Cylindrical dilatations of the inner group of bronchi at the base.

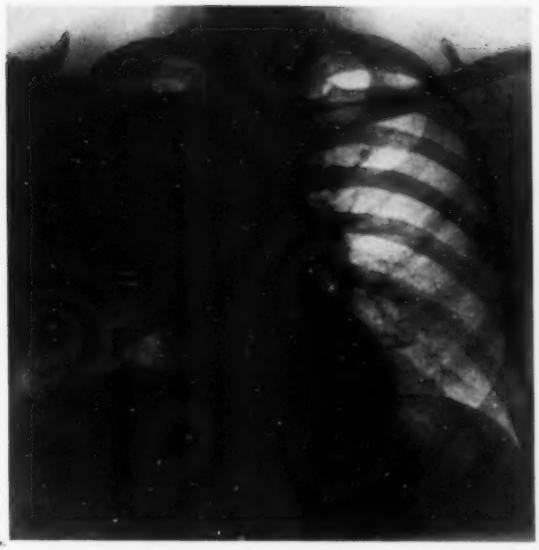


Fig. 26. Case xii. F. G., aged fifty, entered service of Dr. Castillo. Very old abscess with large cavity of the upper right lobe.

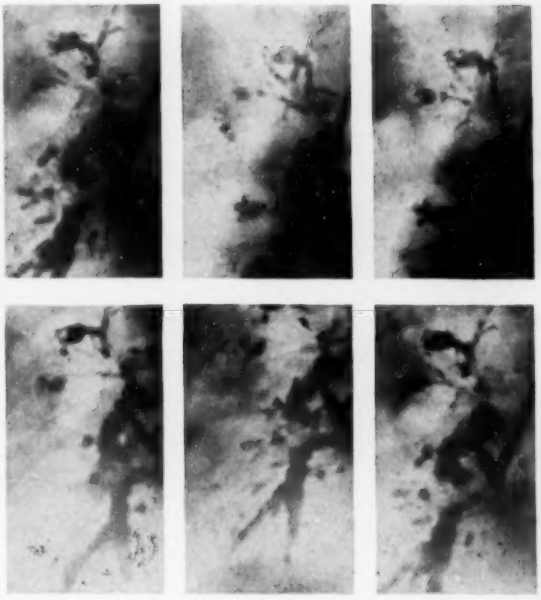


Fig. 27. Case xii. The bronchogram shows large cavity of the lung near the right hilus. Ampullar dilatations of the corresponding bronchi at the base.

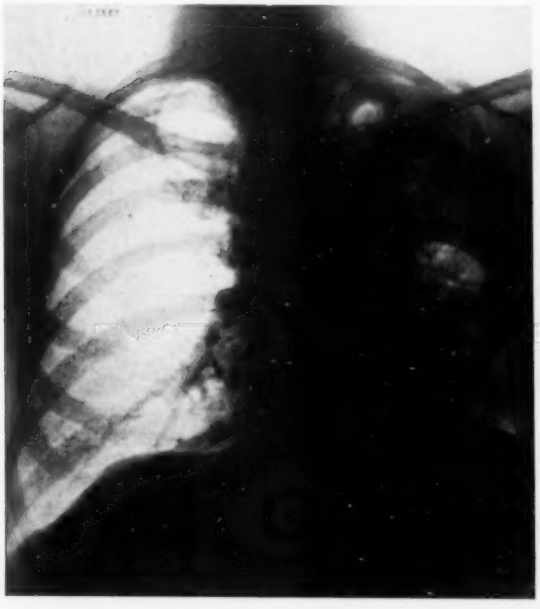


Fig. 28. Case xiii. A. V., aged fifty-four, entered the service of Professor Castillo. For the last two years the patient had abundant expectoration with bad odor and, at times, blood-tinged. The roentgenogram shows an extensive consolidated zone of the upper left lobe and extensive zone of fibrosis of the left base which has increased lately.

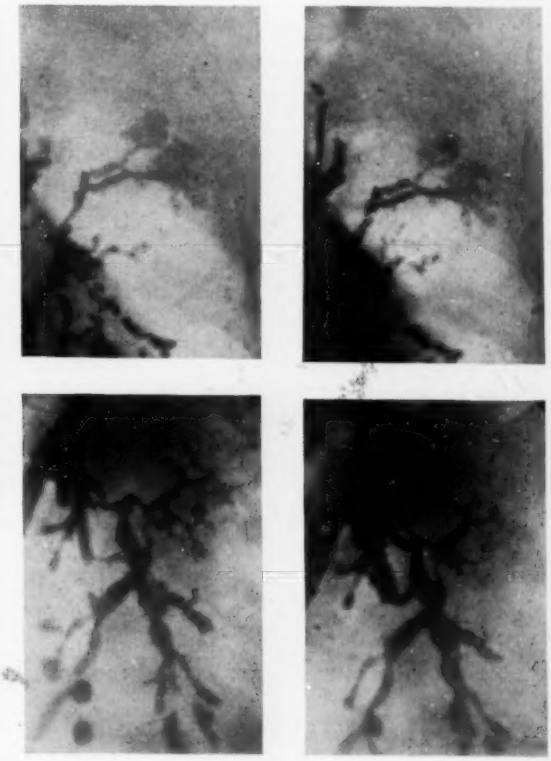


Fig. 29. Case xiii. The bronchogram shows a large irregular cavity of the upper left lobe. The mottled appearance is due to the mixture of iodized oil with the pus in the cavity. Cylindrical, ampullar and sacciform dilatation of the bronchi of the base.

Fig. 30. Case xiv. L. D., aged thirty-four, suffering for two and one-half years with a chronic pulmonary process, with cough, abundant expectoration with bad odor and intermittent fever. The roentgenogram shows an irregular opacity at the left base. The diagnosis is bronchiectasis.

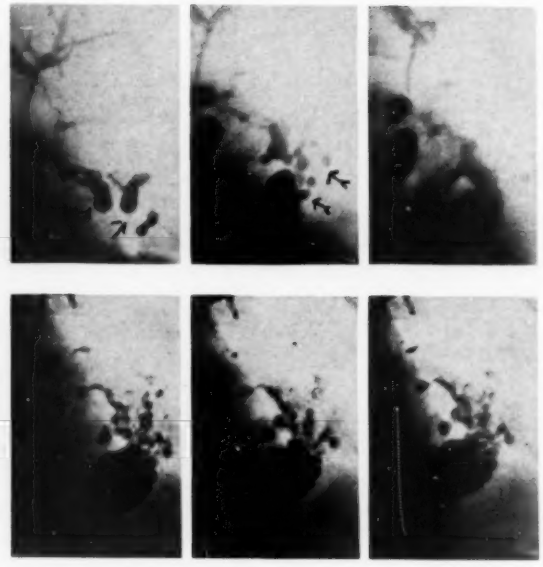


Fig. 31. Case xiv. The bronchogram shows a large cavity, with small round cavity around a cylindrical dilatation of the bronchus of the base.

Fig. 32. Case xv. F. A., aged fifty-six, entered the hospital with abundant purulent expectoration and low irregular fever. The roentgenogram shows an atelectatic right upper lobe.

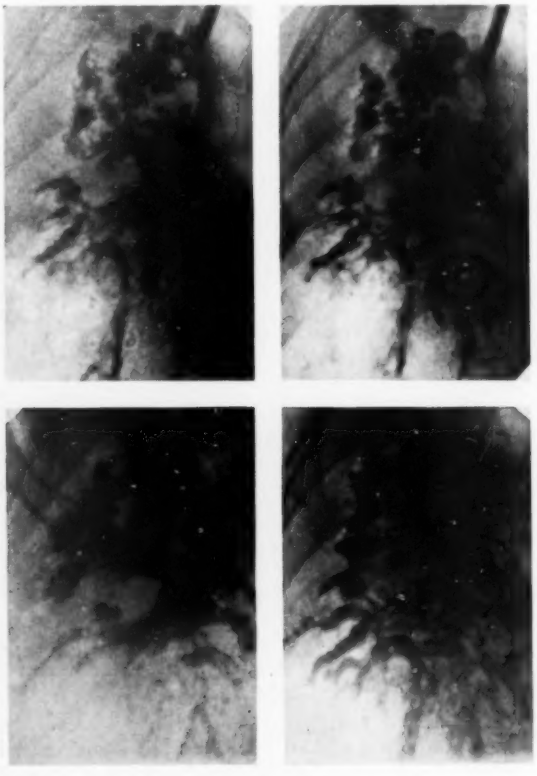


Fig. 33. Case xv. The bronchogram shows typical sacciform bronchiectasis. The necropsy showed an extended sclerosis with bronchial dilatation of the sacciform type.

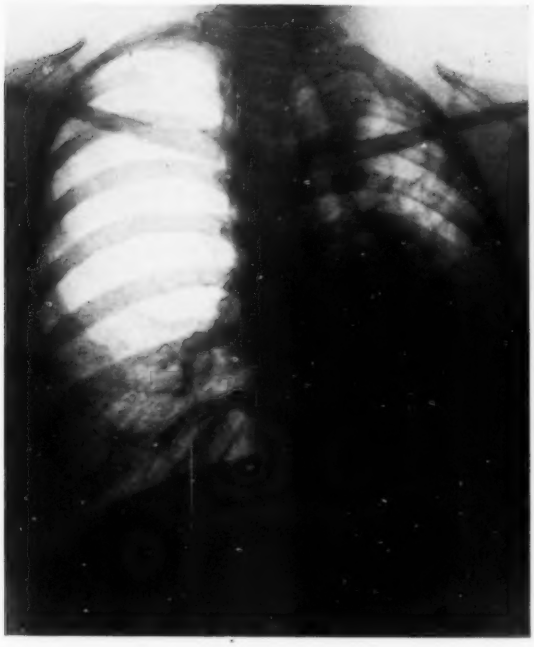
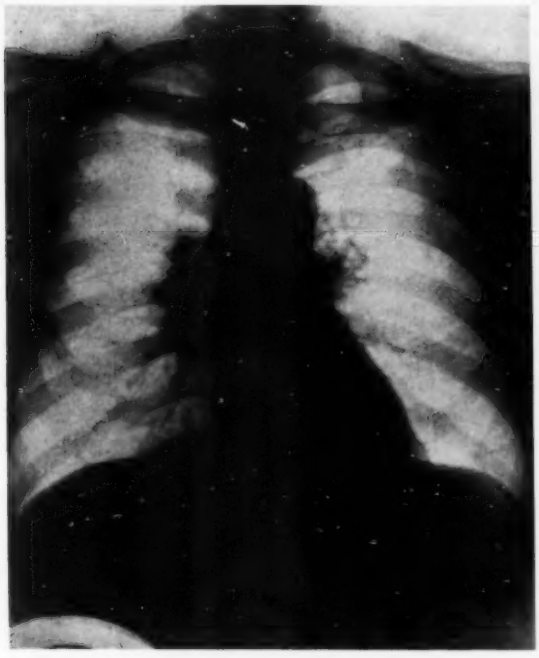


Fig. 34. Case xvi. C. C., aged thirty-five, entered the service of Professor Bisbe. After gynecological operation the patient had high fever, cough and expectoration, the latter increasing, with bad odor at times. The roentgenogram shows large opacity of the left base with displacement of the mediastinum to this side.



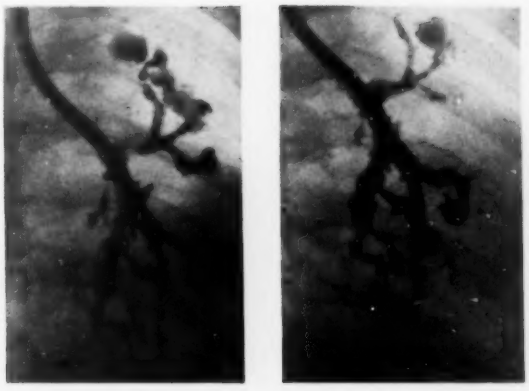


Fig. 35. Case xvi. Bronchogram. At the lower lobe can be seen extensive cylindrical and ampullar bronchiectasis and ampullar dilatations in the upper lobe.

alterations in the bronchi of the corresponding base, no matter how far it is from the abscess (Case viii).

It is well known that the bronchi around the cavity of the abscess are dilated due to the retraction caused by the sclerosis of the pulmonary tissue around them, presenting the sacciform type of dilatation (Case ix).

In nearly all of our cases of abscesses of the upper lobes we have seen dilatations in the internal group of bronchi at the base. We think that this is due to the irritation of the bronchus by infected ma-

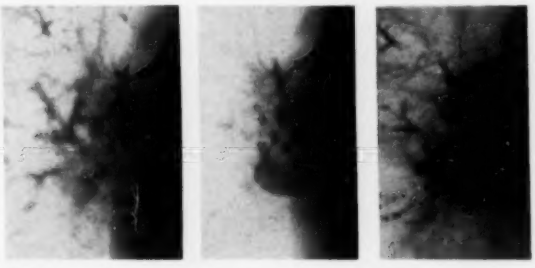


Fig. 37. Case xvii. The bronchogram shows large cavity without sacciform dilatations around. Biopsy: carcinoma.

Fig. 36. Case xvii. V. R., aged sixty-three. For a year has presented cough, bloody expectoration, pain in the right chest and low irregular fever. Decreasing in weight. The roentgenogram shows an ulcerated opacity at the right hilus.

Fig. 38. Case xviii. R. A., aged forty-five. For the last three months has presented pain at the right shoulder, cough, expectoration, sometimes bloody; low fever and decrease in weight. The first roentgenogram shows a round excavated opacity of the right apex.

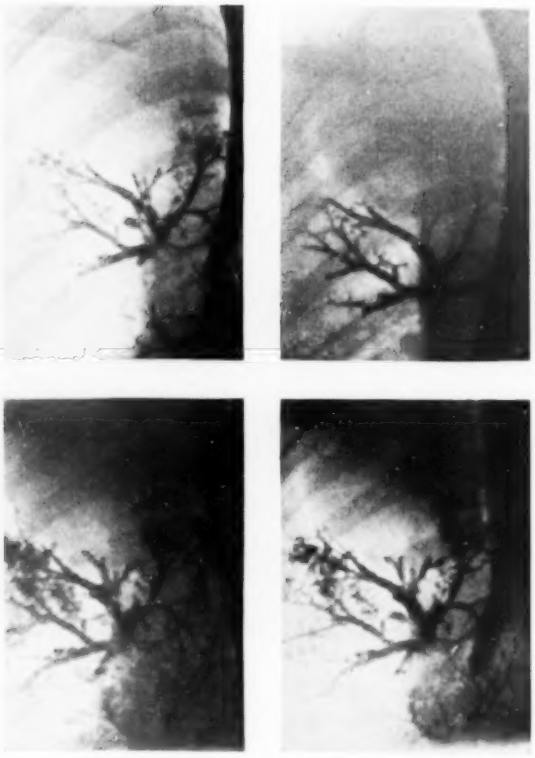


Fig. 39. Case xviii. The bronchogram shows displacement of the whole bronchial tree in the region of the tumor.

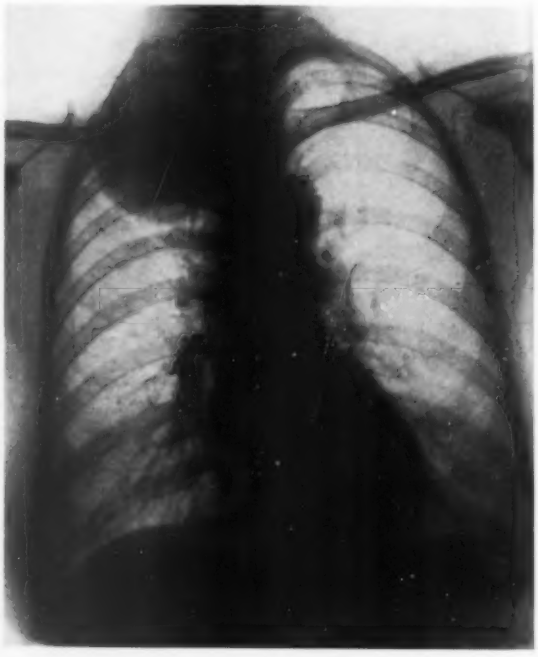


Fig. 40. Case xviii. The roentgenogram two months later shows increase in the size of the tumor. Operation: tumor of the upper pulmonary sulcus.

terial from the cavity, which descends, favored by gravity, into the basal bronchus and remains there because it cannot be easily expelled. In only one case of this series have we seen large abscesses of the upper right lobe without dilatations of the basal bronchus (Case x).

These dilatations at the base of the lung may have all the forms of bronchiectasis. First they are cylindrical when the process is confined to the bronchial wall (Case xi). Later, when the process is older and the peribronchus is invaded, the alterations take the form of ampullar dilatations (Case xii). When the pulmonary parenchyma presents signs of fibrosis, the bronchial alterations will present the mixed form of ampullar and sacciform bronchiectasis (Case xiii).

When the cavity of the chronic abscess is very small, or not visible for some other reason, it is sometimes impossible to dis-

tinguish between a bronchiectatic abscess and an abscessed bronchiectasis. The bronchogram shows sometimes, in cases of bronchiectatic abscess, a larger central cavity and smaller sacciform cavities around it (Case XIV).

In cases of abscessed bronchiectasis all the cavities have about the same size (Case XV).

In cases of extended fibrosis of an inferior lobe by an old abscess, no matter if the roentgenogram shows a small modified upper lobe, it is possible and frequent that there we may find large sacciform dilatations (Case XVI).

It must be remembered that there is a type of bronchial carcinoma, the ulcerating type, that takes place in the large bronchi, which, ulcerating the bronchial wall, produces a cavity, sometimes a large one. In the roentgenogram it shows an identical shadow to that of the pulmonary abscess. The cavity fills with the oil but we do not find the sacciform dilatations of the bronchi around the cavity because in carcinoma the extended area of fibrosis does not exist (Case XVII).

In some cases of ulcerated lobar carcinoma of the lung it may be difficult to distinguish it from a chronic abscess. In the bronchogram the cavity of the lobar carcinoma generally does not fill, the whole bronchial tree at its level is displaced by the tumor. This never occurs with the abscess (Case XVIII).

REFERENCES

1. Castillo, P., Basterrechea, C., and Fariñas, P. Diagnóstico precoz del cancer del pulmón. *Vida nueva*, Suppl., May, 1933.
2. Fariñas, P. L. Aspecto radiológico del absceso del pulmón. *Vida nueva*, February, 1934, *33*.
3. Fariñas, P. L. Serien-Bronchographien zur Frühdiagnose des Bronchialkarzinoms. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1933, *48*, 330–338.
4. Fariñas, P. L. Serien-Bronchographien zur Diagnose der Lungeneiterungen. *Röntgenpraxis*, 1934, *6*, 569–582.
5. Fariñas, P. L. Bronchographic aspects of the chronic pulmonary abscess. Presented before the Fourth International Congress of Radiology, Zurich, Switzerland, 1934.

# OBLIQUE FILMS FOR THE STUDY OF ADHESIONS IN ARTIFICAL PNEUMOTHORAX*

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WITH the increasing use of artificial pneumothorax in the treatment of tuberculosis, and especially with the development of intrapleural pneumolysis, a detailed knowledge of mechanical conditions within the pneumothorax space of each individual patient has become of the greatest importance. There are few cases of tuberculosis in which the pneumothorax space is entirely free of adhesions. Some of these adhesions are of no importance, while others definitely interfere with the effectiveness of the pneumothorax and must be divided before the collapse can be considered satisfactory.

Before we attempt to divide intrapleural adhesions, however, we must know as exactly as possible the number present, their points of origin, and the direction in which they run. We also want as much information as we can get as to their relative technical importance—which ones are the chief factors in preventing proper collapse, or in holding open a cavity. Such adhesions cannot be demonstrated by any physical findings, as they produce neither signs nor symptoms, and it is only through the roentgen-ray examination of the chest that we have been able to appreciate their presence. A complete roentgen examination should of course include both roentgenography and roentgenoscopy. Of these two, the examination of suitable films is by far the more important, for although we can see many adhesions at the roentgenoscope there are many more that cannot be visualized, due to their delicacy. The usual posteroanterior film of the chest, however, shows only a profile view of the collapsed lung and there are important areas of pneumothorax lying between the lung and the anterior chest wall, and the lung and the posterior chest wall, that are not visualized in this projection. At times technically important adhesions lie in these areas.

Even stereoscopic films are of but little value in this connection because adhesions which are parallel to the main beam of the roentgen ray are not visualized, or usually they are lost in the shadows cast by the collapsed lung. It is obvious that any technique of roentgen examination that will visualize these areas will be a great aid in the selection of patients for intrapleural pneumolysis and in the operative attack on such adhesions.

It was in an effort to better this situation that I began using oblique exposures of the hemithorax in which the pneumothorax existed. It was found, by using a lead screen covering half a 14″×17″ cassette the long way, and changing it between exposures, that both oblique views could be taken on one film, and that this, in association with one posteroanterior exposure, gave more information than a stereoscopic pair. The angle of rotation used was about 45 degrees from the plane of the film, as this was found most satisfactory. Further rotation in the anterior oblique will throw the shadow of the sternum into the pneumothorax space and confuse the picture, while in the posterior oblique the shadow of the spinal column will overlie the pneumothorax.

In placing the patient before the cassette to take the posterior oblique exposure the forearm on the pneumothorax side should be placed across the small of the back, as this position throws the humerus out of the picture. In taking the

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anterior oblique exposure the arm on the side to be filmed should be rotated inwards and the point of the shoulder brought as far forward as possible. The tube, of course, should be centered over the middle of the unprotected half of the film for each exposure. It was also found satisfactory to use the same exposure technique as for the posteroanterior position, except that the time was doubled.

Figures 1 and 2 show diagrammatically the position for taking the anterior and

Fig. 1

posterior oblique views, respectively, of a pneumothorax on the right side. They also show how an adhesion located in front of or behind the collapsed lung, that cannot be seen in the anteroposterior view, may be visualized in these positions.

There are, however, adhesions that are so located as to be visualized in all three positions. The exact localization of these is more difficult and depends on the fact that in the different positions the adhesion seems to vary in length, being shortest as it lies most nearly parallel to the central beam of the roentgen ray, and being longest as it lies more in a plane at right angles to the beam. This is shown diagrammatically in Figure 3. Here 1 represents the projection of the adhesions in the postero-

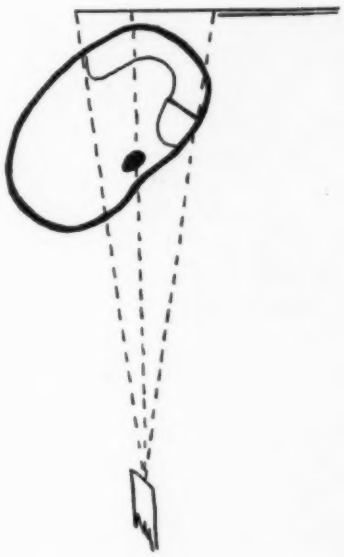

Fig. 2

anterior view; 2 and 3 show the length of the adhesions as seen in the anterior and posterior oblique positions respectively. It will be seen that the adhesion appears shortest in 2, the anterior oblique view, and longest in 3, the posterior oblique view. The length of the projection in the posteroanterior position lies between these two, but closest to that of position 3. The adhesion therefore runs to the posterolateral wall.

Recently Greenberg has drawn attention to the fact that a partial pneumothorax is more readily demonstrated in the

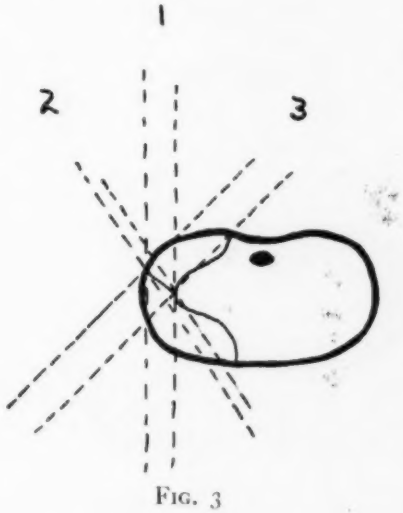


Fig. 3

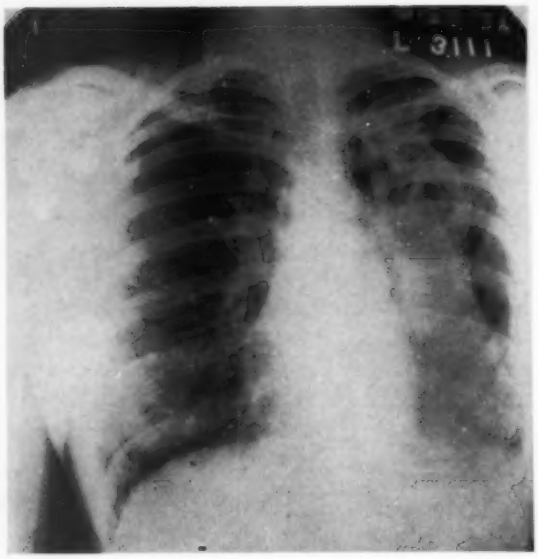

Fig. 4

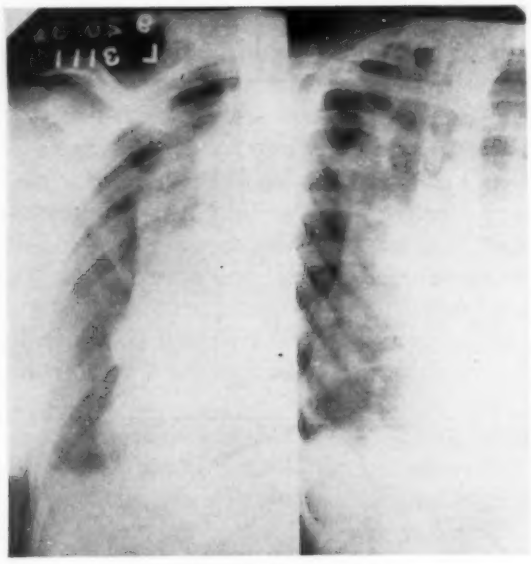

Fig. 5

expiratory phase of respiration. This observation can be utilized in studying adhesions because during expiration they are stretched to their full length by the neutral or positive intrapleural pressure, and in addition the pneumothorax, by occupying a larger percentage of the hemithorax, brings them into greater relief.

Figures 4 and 5 are reproduced from films taken as outlined above. Figure 4 is a posteroanterior exposure but is viewed here from the position of the film. Figure 5 shows the two oblique exposures on one film. It is viewed from the position of the tube, the anterior oblique on the left and the posterior oblique on the right. These are made in accordance with the diagrams (Figs. 1 and 2). In the posteroanterior view the lower part of the pneumothorax space seems free of adhesions but in the anterior oblique a large dense adhesion is seen crossing this space at the level of the

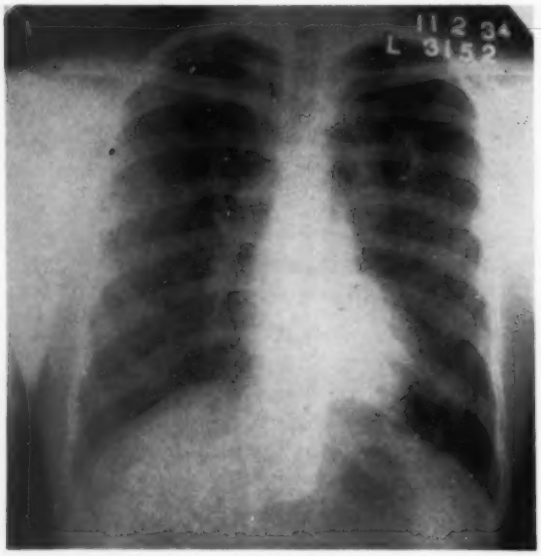

Fig. 6

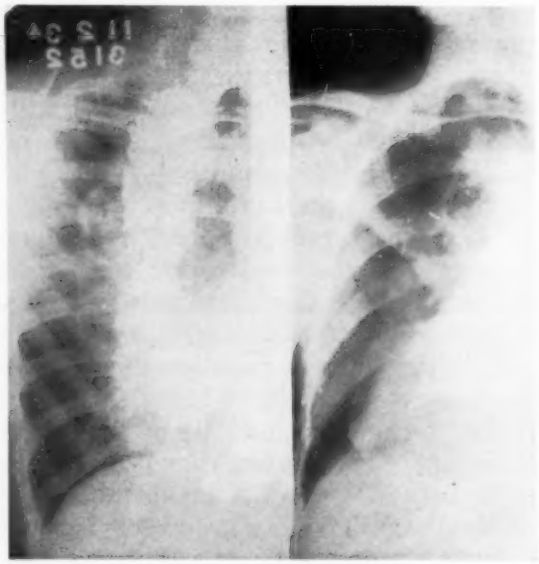

Fig. 7

seventh rib posteriorly. This particular adhesion is of no technical importance but was selected for reproduction because its position and density made it easier to see.

Figures 6 and 7 are reproduced from films showing the condition diagrammed in Figure 3. In the posteroanterior view (Fig. 6), the adhesion can readily be seen running apparently to the lateral chest wall. However, it can also be seen in both oblique views but here it varies greatly in length being shortest in the posterior oblique. Actual measurement on the film of the length of the adhesion in the various projections showed it to be longest in the anterior oblique. From these films therefore it was localized as running to the anterolateral chest wall at about the level of the second rib. At operation by Dr. Richard Meade for the division of this adhesion it was readily seen through the thoracoscope and found to be in the position as localized by the roentgenograms.

SUMMARY

It is pointed out that there are important areas of artificial pneumothorax lying between the collapsed lung and the anterior and posterior chest wall.

Pleural adhesions of great technical importance may lie in these areas.

Stereoscopic films in the usual projection fail to visualize these areas.

The value of oblique films for the detection of adhesions lying in these areas of the pneumothorax space is considered and a technique for taking them is outlined.

The interpretation of these films is discussed.

# KIDNEY FUNCTION IN ACUTE CALCULOUS OBSTRUCTION OF THE URETER

## SOME OBSERVATIONS OF KIDNEY AND URETER FUNCTION IN ACUTE CALCULOUS OBSTRUCTION OF THE URETER, BASED ON EXCRETORY UROGRAPHY

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THE purpose of this paper is to emphasize one of the variations of kidney function which, while not new, is not generally appreciated. We wish also to offer an explanation for this disturbance in function.

It is a known fact that in cases of acute obstruction of a ureter due to calculus, there is not only a possible retardation in the formation of the urine in the kidney on that side, but also a very definite delay in its drainage from the renal tubules.

The roentgenologist hesitates to complete a diagnosis of disease of the gastrointestinal tract without the observations of the function of the various segments of the tract during the study. So also in interpreting studies of intravenous urography it is imperative that he have a fundamental knowledge of kidney function.

Great progress has been made in the study of the function of the kidney and ureter since 1928 when Jarre designed cameras to study renal and ureteral peristalsis, and with the advent of excretory urography the desired method was obtained for the roentgen study of renal function.

There are several factors besides disease which may influence kidney and ureteral function and these are (*a*) the use of diagnostic instruments such as the cystoscope and ureteral catheter just prior to the intravenous urographic study and (*b*) the injection of drugs into the body tissues hypodermically or intravenously. The roentgenologist must be aware of these facts, which means, then, that he must have an accurate clinical history and be in close contact with the patient during the study.

In acute calculous obstruction of the ureter, certain characteristic findings are evident in excretory urography. These may be illustrated by 3 cases.

CASE 1. J. L., male, aged thirty, single. The past history was negative. About 8:00 A.M., August 27, 1932, the patient began to have dull pain in the right lower abdomen which gradually increased in severity until it became unbearable. The pain did not radiate from this area. He became nauseated and vomited once. The temperature was 98.6° F. and the pulse rate 72. The white blood count was 4,550, with 77 per cent polymorphonuclears. The urine examination was negative for albumin but there were many red blood cells. Physical examination revealed slight tenderness in the right lower quadrant of the abdomen with some muscle spasm.

At 11:45 A.M. a film was made of the urinary tract. There was a small shadow of lime density measuring about 2 mm. in diameter in the approximate course of the lower right ureter. The patient was having considerable pain and he was given morphine sulphate gr. 1/4 at 11:45 A.M. Neo-iopax was injected intravenously at 12:00 M. A film made five minutes after the injection revealed a fair pyelogram and ureterogram on the left side with some opaque medium in the bladder. The density of the right kidney shadow was very definitely increased but there was no opaque medium in the calyces or pelvis or in the right ureter. The patient was still having some pain, although it had been partially relieved. A few minutes later, or about twenty-five minutes after the injection of the morphine, he felt relatively comfortable. A film made fifteen minutes after the injection of the neo-iopax revealed a pyelo-

gram of low density on the right side, with the upper ureter visualized. The shadow of lime density was still evident in the course of the lower right ureter. At thirty minutes, there was excellent visualization of the calcyes and pelvis of the right kidney and the entire ureter to the level of the shadow of lime density just above the ureteral orifice. A diagnosis was made of an acute calculous obstruction of the right ureter.

The patient still felt comfortable the following day and was discharged from the hospital. The next day he returned for a cystoscopic examination. A catheter was passed into the right ureter. The urologist's report was: "Obstruction 1 cm. from orifice with grating. Manipulated until a small stone presented at orifice and passed."

During an intravenous pyelographic study, we keep the patient on the table for at least the first twenty minutes if possible and the films are developed immediately and viewed. The findings in this case interested us and we made a few notes on the exact condition of the patient at the time our studies were made.

Case II. R. W., male, aged twenty-eight, single. One year previously this patient had

Fig. 1. Case II. Preliminary film. Calculus 2 mm. in diameter in right lower ureter. Note density of each kidney shadow at this time.

Fig. 2. Case II. Intravenous urography thirty minutes after injection of neo-iopax. Normal pyelogram and ureterogram on left. Calculus in lower right ureter. No pyelogram or ureterogram on right. Note great increase in density of right kidney shadow as compared with Figure 1.

been operated on for the removal of a calculus of the left ureter. On September 4, 1932, he began to notice some pain in the right side of the abdomen which extended down to the right groin. The pain was not very severe and was not constant. He had some nausea and vomiting. The morning of September 6, the pain in the right lower quadrant and groin became more severe and was continuous. Urine and blood studies were not obtained. Physical examination revealed moderate tenderness in the right lower quadrant of the abdomen.

The patient was admitted to the Roentgen Department only and a film was made of the urinary tract. This revealed a small shadow of lime density measuring about 2 mm. in diameter in the pelvis in the region of the right ureteral orifice (Fig. 1). Gas and fecal material in the bowel partially overshadowed this area. At 11:30 A.M. he was given a hypodermic of morphine sulphate gr. 1/4 and atropine sulphate gr. 1/150. At this time neo-iopax was injected intravenously. Films were made at five, fifteen, thirty and sixty minutes. At five

minutes there was a pyelogram and ureterogram of fair density on the left side, but no opaque medium appeared in the kidney calyces or pelvis or in the ureter on the right side. This same finding was present at fifteen and at thirty minutes. The density of the right kidney shadow had greatly increased, however (Fig. 2). The patient still complained of pain in the right lower abdomen. About fifty minutes after the neo-iopax injection, the pain had disappeared. At sixty minutes, a film was made and this revealed a pyelogram and ureterogram

Fig. 3. Case II. Intravenous urography sixty minutes after injection of neo-iopax. Pain relieved and excellent pyelogram and ureterogram on right. Note decrease in density of right kidney shadow as compared with Figure 2.

of excellent density on the right side. The shadow of lime density persisted and lay in the course of the right ureter at its lower end, being visible through the bladder shadow. The density of the right kidney shadow had decreased (Fig. 3).

A diagnosis of acute calculous obstruction of the lower right ureter with repression of right kidney function was made.

The patient was able to return home and, according to his family physician, progress has been uneventful.

Case III. J. C., male, aged sixty-three, married. The past history was negative. On March 25, 1933, about 4:00 P.M. he had a sudden attack of severe knife-like pain in the right side of the abdomen. There was no definite radiation of the pain but he was nauseated and vomited. The temperature was 98.6° F. and the pulse rate 80. The white blood count was 13,600, with 84 per cent polymorphonuclears. The urine examination was negative for albumin but there were many red blood cells. Physical examination revealed generalized abdominal tenderness with marked rigidity on the right side. There was also some tenderness on pressure over the right kidney region. At 5:20 P.M. he was admitted to the hospital and given morphine sulphate gr. 1/6 hypodermically.

At 8:30 P.M. a film was made of the urinary tract. There was a small shadow of lime density about 3 mm. in diameter below the right sacroiliac joint and in the approximate course of the right ureter. Following this, neo-iopax was injected intravenously. The patient continued to have abdominal pain. Films were made at seven, eighteen and thirty-five minutes. At seven minutes there was a pyelogram of fair density on the left side and partial filling of the left ureter. There was no pyelogram on the right side. At eighteen and thirty-five minutes, there was still the same finding except that the density of the right kidney shadow had increased over that of the first film. No further films were made.

A diagnosis of right ureteral calculus with repression of right kidney function was made.

Two days later the patient was cystoscoped and a catheter was left in the right ureter. The catheter was removed the next day and the report made by the urologist stated there was some grating. The patient left the hospital several days later and his clinical course has been uneventful.

These 3 cases suggest to us several things:

1. In acute calculous obstruction of the ureter, there is a retardation of the urine secretion from the kidney on that side and no pyelogram or ureterogram is obtainable.

2. The kidney function does not cease as there is increased density of the kidney shadow.

3. The urine containing the opaque medium is prevented from draining into the kidney calyces from the tubules.

4. While the patient experiences pain the function of the kidney is repressed but when the pain is relieved, secretion immediately returns to a relatively normal level, an excellent pyelogram and ureterogram being obtained with decrease in the density of the kidney shadow.

5. The pain in acute calculous obstruction of the ureter is produced by the increased pressure and the distention of the ureter, kidney pelvis and kidney capsule and not by the presence per se of the calculus in the ureter producing spasm.

6. Morphine relieves the obstruction and at the same time the pain and then the kidney function returns to nearly normal.

7. The calculus may or may not be visualized on the film, but its presence is suggested by the repression of kidney function.

In these observations we have referred entirely to those cases in which a calculus was the causative factor in the acute obstruction. There are some cases of acute obstruction in which no calculus is demonstrated. We do not know if this repression of kidney function occurs in such a case in which the obstruction is not due to a calculus, but we believe it does. Certain calculi are not demonstrated on the film but later the patient may appear with the calculus which has been passed.

## HOW DOES THE CALCULUS PRODUCE A RETARDATION OF URINE FORMATION?

To answer this question we must review our present knowledge of urine secretion and also the nerve supply of the kidney and ureter. Braasch[1] of the Mayo Clinic and Wesson and Fulmer[7] of San Francisco have stated that there is a reflex inhibition of urine. This is also referred to as a suppression of urine. We believe that the urine formation is not completely arrested and that the term "repression of urine" should be used rather than "suppression." We believe, also, that a nerve reflex is not the entire explanation of this repression but that an increase in the pressure in the uriniferous tubules acts also to produce this result.

In attempting to explain the retardation of urine formation and the absence of a pyelogram and ureterogram in the presence of an acute calculous obstruction, we wondered if it would be possible to reproduce these observations experimentally in animals. Therefore we undertook an experiment to mechanically block one ureter of a rabbit and study roentgenologically the function of both kidneys by means of excretory urography.

Before we review the present knowledge of urine secretion and the nerve supply of the kidney and ureter, we will give the results of these experimental studies.

## EXPERIMENTAL STUDIES

*Experiment 1.* Using an adult male rabbit weighing 3,100 grams, a preliminary film was made of the urinary tract. The lower left ureter was exposed through a lower left abdominal incision, under local anesthesia, using 1 per cent novocaine in the tissues. A rubber protected hemostat was placed on the lower left ureter about 1 inch above the bladder and this completely obstructed the ureter, without undue trauma to the ureteral tissue. The clamp was left on the ureter for ten minutes and then another film was made. No difference in the density of the kidney shadows on the two films was noted. Immediately following this 4 c.c. of neo-iopax was injected intravenously. This amount of neo-iopax was about 1 gram per kilogram of body weight. A film was made one minute after the injection of the neo-iopax and at this time there was an increase in the density of both kidney shadows, but with the density of the left kidney shadow slightly greater. A pyelogram and ureterogram were obtained on the right side and some of the opaque medium was present in the left kidney pelvis. Films were made at four and five minutes after the neo-iopax and the density of the left kidney shadow increased more than that of the right kidney. The size of either kidney shadow had not appreciably changed. The clamp was then removed from the left ureter, making certain that drainage of urine from the left ureter into the bladder was re-established. Films were made at one and three minutes after removal of the clamp and in both of these the density of the

left kidney shadow had decreased so that it was equal to that of the right kidney. Also a complete ureterogram was then obtained on the left. The rabbit was autopsied and no macroscopic changes were noted in either kidney.

In reviewing the results obtained in this experiment, we noted that the blocking of the left ureter for ten minutes before the injection of neo-iopax produced an increase in the density of the left kidney shadow as compared with the right, but still there was filling of the left kidney pelvis with the opaque medium. We concluded that the duration of complete block of the left ureter before the injection of the neo-iopax (ten minutes) was not adequate to produce sufficient pressure in the ureter, kidney pelvis and calyces. Therefore it was decided to repeat the experiment, blocking the ureter for a longer period of time.

*Experiment 2.* Using a male rabbit of 3,225 grams, the lower left ureter was blocked by the same method as in the previous experiment, after a preliminary film had been made of the urinary tract. The clamp was left on the ureter seventy-five minutes before neo-iopax was injected, but at sixty minutes a second film was made. This revealed a definite increase in the size of the left kidney as compared with the first film and also some increase in the density of its shadow.

At seventy-five minutes, 4 c.c. neo-iopax was injected intravenously and a film was made one minute later. This revealed a pyelogram and ureterogram on the right side, but no opaque medium in the left kidney pelvis or calyces and the shadow of the kidney had markedly increased in density. A film made fourteen minutes after the injection revealed still no opaque medium in the left kidney pelvis or calyces and a further increase in the density of the kidney shadow. The density of the left kidney shadow was then very much greater than that of the right kidney. The clamp was then removed from the left ureter, and a film made one minute later revealed a pyelogram and ureterogram of low density on the left side and already some decrease in the density of the left kidney shadow, with definite decrease in its size. A film was made thirty minutes after the removal of the clamp and in this an excellent pyelogram and ureterogram were obtained, and the density of the left kidney shadow had further decreased. Films were made at six, twenty and thirty-five minutes after the release of the block in the ureter. These revealed a further decrease in the size and density of the left kidney shadow. The left upper ureter was then opened and the urine drawn from the kidney pelvis was found to be slightly hemorrhagic. This rabbit was necropsied but no macroscopic changes were noted in either kidney.

The results of this second experiment indicated that a complete block of the ureter for seventy-five minutes produced some increase in the density of the kidney shadow and also some increase in its size. When the neo-iopax was injected intravenously, the blocked kidney increased markedly in density, but none of the opaque medium drained into the kidney calyces, pelvis or the ureter. Immediately on removing the block in the ureter, the opaque medium filled the kidney calyces, pelvis and the ureter and drained into the bladder. The density of the kidney shadow also returned to normal. Here we had been able to approximately reproduce the findings which we had observed in our clinical cases, particularly Case II. A complete block for seventy-five minutes had been sufficient to increase the pressure in the drainage system so that none of the opaque medium reached the kidney calyces. The finding of a slightly hemorrhagic urine in the kidney pelvis indicated, we believe, that some damage had been done to the renal cortical tissue, due to the great pressure resulting from a complete block of the ureter for ninety minutes.

We decided to repeat the experiment and block the ureter for a shorter period of time so that no damage would be done to the kidney tissue and yet produce, if possible, the findings as in Experiment 2.

*Experiment 3.* Using a male rabbit of 2,950 grams, the experiment was repeated, blocking the left ureter for a period of twenty-five minutes before 4 c.c. of neo-iopax was injected. After the injection of the neo-iopax the left kidney shadow increased in density very much more than the right kidney shadow, but the calcyces of the left kidney filled with the opaque medium. The pelvis of the kidney and the ureter did not fill even up to twelve minutes after the injection. After the removal of the clamp from the ureter, an excellent pyelogram and ureterogram were obtained and the density of the left kidney shadow returned to normal. Necropsy study of the kidneys revealed no macroscopic changes.

In this experiment, the block of the ureter for twenty-five minutes was not sufficient to prevent the opaque medium from reaching the

kidney calyces. The density of the kidney shadow had, however, increased, and returned to normal after the block was removed.

*Experiment 4.* The experiment was repeated using a male rabbit of 3,000 grams and injecting 4 c.c. of neo-iopax. This time the left ureter was blocked for forty-five minutes before the injection of the neo-iopax. The block of the ureter for forty-five minutes produced a slight increase in the size and density of the left kidney and after the neo-iopax was injected there was a marked increase in the density of the left kidney shadow. There was, however, a small amount of the opaque medium in the pelvis of the left kidney. When the block was removed from the ureter twenty minutes after the injection, the kidney pelvis and the ureter were well filled and the density of the kidney shadow returned to normal. The necropsy study of the kidneys revealed no macroscopic changes.

This experiment revealed that a block of the ureter for forty-five minutes was not sufficient to prevent some of the opaque medium reaching the kidney pelvis. The changes in the size and the density of the kidney shadow were noted as before.

Fig. 4. Experiment 5. Preliminary film of urinary tract of rabbit.

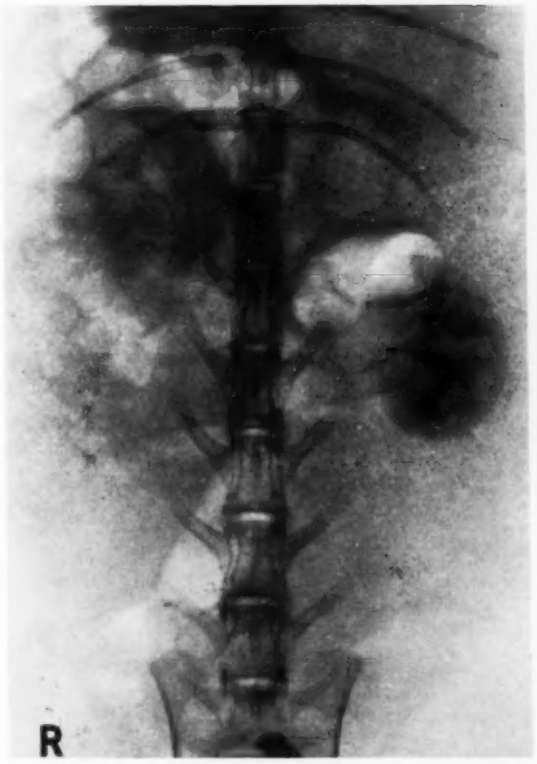


Fig. 5. Experiment 5. Intravenous urography in rabbit twenty minutes after injection of neo-iopax and eighty minutes after block of left ureter. Pyelogram on right but none on left. Note the marked increase in the density of the left kidney shadow.

*Experiment 5.* Using a male rabbit of 3,150 grams, a preliminary film was made (Fig. 4) and the left ureter was blocked for sixty minutes. A second film was then made and 4 c.c. of neo-iopax was injected. A film made twenty minutes after the injection revealed a good pyelogram on the right side, but none on the left (Fig. 5). The density of the left kidney shadow was greater than that of the right and the left kidney shadow had increased in size. The clamp was then removed and three minutes later there was a fair pyelogram and ureterogram on the left side. A film made at ten minutes showed decrease in the density of the left kidney shadow (Fig. 6). Examination of the urine from the left kidney showed it to be normal. Necropsy study of the kidneys revealed no macroscopic changes.

The results of this experiment indicated that a block of the rabbit ureter for sixty minutes was sufficient to prevent drainage of the opaque medium into the kidney pelvis on that side and

yet there was not sufficient pressure to produce damage to the renal tissue. Thus, for the rabbit, we considered this block of sixty minutes to be the optimum time. We had here reproduced the findings of our clinical cases, especially Case II.

### THE PRESENT KNOWLEDGE OF URINE FORMATION

Two theories of renal function have been advanced in the past. The first is that of Bowman and Heidenhain and is known as

FIG. 6. Experiment 5. Intravenous urography ten minutes after removal of block from left ureter. There is now a good pyelogram on the left and a very definite decrease in the density of the left kidney shadow.

the "vital theory." This theory states that the glomerulus secretes the water and inorganic salts but the urea is produced in the uriniferous tubule by secretion by the cells. This view claims a vital property for the cells.

The second theory, that of Ludwig, is the so-called "mechanical theory." The urine is formed by the simple filtration through the glomerulus of all its constituents, water, inorganic salts and urea. In the tubule the urine is concentrated by a resorption of water.

The present view of urine formation held by most physiologists and sometimes called the Cushny theory is a combination of the two old theories. The cells in the glomerulus act as a filter allowing all the constituents of the urine to pass but the cells in the tubule resorb both fluids and salts from the glomerular filtrate and therefore must have a vital activity. Some believe that some of the cells may also secrete.

The filtration of the blood fluid through the renal capsule in the glomerulus depends on certain factors:

1. There must be a difference in the pressure between the blood and the urinary filtrate. The pressure used in filtering is furnished by the pressure of blood in the glomerular vessels.
2. The character of the filter determines what substances shall pass. The renal capsule is normally impervious to the proteins of the blood but pervious to the other constituents.
3. The character of the fluid determines how readily it will filter through the capsule.

Three main factors influence this difference in pressure between the blood and the urinary filtrate: (*a*) the volume of blood in the capillaries of the glomerulus; (*b*) the pressure of blood in the capillaries of the glomerulus; (*c*) the pressure of the urine in the uriniferous tubule.

If the volume of the blood or the pressure of the blood in the glomerular capillaries is increased, the urine secretion is increased. Richards[6] of Philadelphia states that only in the glomerular capillaries can an increase of pressure in the renal circulation produce an increase in the amount of urinary filtrate. If the pressure of the urinary filtrate in the uriniferous tubule, and thus in the kidney pelvis, is increased, the urine secretion is decreased. The volume of blood and the pressure in the capillaries are controlled by nerves to the kidneys.

### INNERVATION OF KIDNEY AND URETER

The nerve fibers to the kidney are derived from the sympathetic nervous system and they are both vasoconstrictor and vasodilator in function. These fibers end in the kidney about the capillaries both in the glomeruli and about the tubules. At present there is no knowledge of true secretory nerve fibers to the cells in the tubule. The nerves of the kidney are derived from the renal plexus which is formed by branches from the celiac plexus. These nerve fibers reach the kidney by the renal pedicle, being intimately distributed about the renal artery and vein. The renal plexus communicates with the spermatic plexus. The ureter has an independent nerve supply from the abdominal sympathetic system through the aortic, hypogastric and pelvic plexuses and also from the spermatic plexus. Also it is believed that the ureter receives a nerve supply through the renal pedicle. Thus we see there is a relatively direct communication between the nerves of the ureter and the kidney. Wharton[8] states that evidence has been given that the motor fibers to the ureter pass only through the renal pedicle and that the fibers which reach the ureter independently are not concerned with the maintenance of ureteral peristalsis but that they contain afferent fibers and one of the functions of these nerves is the transmission of painful sensations.

### THE EVIDENCE OF A NERVE REFLEX REPRESSION OF URINE

In an acute calculous obstruction of the ureter a stimulus from the irritated ureter may well produce a reflex stimulation of the vasomotor fibers of the arteries, arterioles and capillaries of the kidney, producing a vasoconstriction and thus a diminution in the urine secretion. Richards[6] states that the arteries and arterioles of the kidney are so constricted by the nerve stimulation that despite any increase in aortic blood pressure, the glomerular blood pressure must be lessened. Therefore a nerve reflex repression of urine may be a partial explanation of the decreased secretion when an acute calculous obstruction of the ureter occurs.

### EVIDENCE OF INCREASED INTRATUBULAR PRESSURE PRODUCING A REPRESSION OF URINE

It has been shown by experiment that the pressure in the ureter when it is obstructed rises to 50 or 60 mm. of mercury when measured by a manometer. It is believed that the capillary blood pressure in the kidney is lower than this, but it cannot be proved. Richards[6] states that in the frog the average of many determinations of blood pressure in the glomerular capillaries is about 50 per cent of the aortic pressure. Experiment has also shown that if the pressure in the uriniferous tubule becomes greater than that in the glomerular capillaries, the secretion of urine will be diminished. Obstruction of the ureter by a calculus therefore will produce an increase of pressure in the uriniferous tubule and urine secretion will be diminished. The experiments which we performed on 5 rabbits indicated that if the ureter was obstructed for an hour, there was sufficient pressure established in the uriniferous tubules to prevent drainage of the opaque medium.

### WHY DO WE BELIEVE THAT THE URINE SECRETION IS ONLY DIMINISHED AND DOES NOT CEASE ENTIRELY?

In a case of acute calculous obstruction of the ureter, the density of the shadow of the kidney structure, e.g., the parenchyma, increases greatly as is shown in Case II and in each of the experiments on the rabbits in which the ureter was blocked. This fact, we believe, is evidence that the secretion of urine does not cease completely. The iodine compound producing this increased density must be in one of two locations: (*a*) in the blood stream in the kidney, namely, the glomerular and tubule capillaries, or (*b*) in the uriniferous tubules. It cannot be maintained in the blood stream in the kidney because the renal cir-

culation is not impaired and the iodine compound would be carried away and gradually removed from the circulation by the other kidney. If the blood circulation did cease or diminish, the amount of the iodine compound in the kidney tissues should also be diminished and the density of the kidney shadow should at least not be increased. Therefore we believe the iodine compound must be in the uriniferous tubules and urine secretion must continue after reflex repression due to vasoconstriction or to the increased pressure in the kidney pelvis and tubules, or to both these factors.

If, as we have attempted to show, the urine is still being secreted after the ureter is blocked and the pressure in the kidney has increased, it is strong evidence that at least some of the constituents of the urine must be resorbed into the renal blood stream by some of the cells of the tubules. This would substantiate the present conception of a vital function of the cells of the tubules as is held in the modern theory of urine secretion. Also if the urine formation continues and the urine is concentrated in the tubules by the resorption of water and salts, it is possible that there is not an actual retardation of the formation of the urine, at least to the degree which we had previously supposed.

Why do we believe that the pain is due to the increased pressure and the distention of the ureter, kidney pelvis and kidney capsule by the column of urine and not due to a local spasm of the ureter at the site of the calculus? We observe in Case II that when the drainage of the urine from the pelvis of the kidney is resumed, following relief of the obstruction, the pain has ceased. It has been shown, also, in similar cases that when the urine thus retained in the ureter and kidney pelvis is drained off by ureteral catheterization, with the catheter passed beyond the obstruction, instantaneous relief is experienced by the patient.

## COMMENT

We observe that if excretory urography is performed during the period of an acute calculous obstruction of the ureter, there is none of the opaque medium in the kidney calyces, pelvis or the ureter on the affected side, and the kidney shadow on that side is greatly increased in density. If the obstruction is removed, there is immediate filling of the kidney calyces and pelvis with the opaque medium and the density of the kidney shadow decreases. Experimental studies on the rabbit, using excretory urography, after blocking the ureter for sixty minutes, reveal the same findings. The non-appearance of the opaque medium in the kidney calyces has been ascribed to a reflex inhibition of urine. We believe the experimental study would indicate that urine formation in the kidney continues to a degree and that the increased pressure in the drainage system from that kidney prevents in a mechanical manner the escape of the opaque medium from the uriniferous tubules into the calyces. We offer this explanation as being the chief if not the entire reason for the non-appearance of the opaque medium in the kidney calyces.

We also suggest that the term "repression of urine" would be more strictly correct than "suppression of urine" as it indicates that the formation of urine by the kidney units does not cease.

## CONCLUSIONS

1. In acute calculous obstruction of the ureter, there is a marked delay in the drainage of the urine from the uriniferous tubules into the kidney pelvis and possibly a repression of the urine secretion in that kidney. This is due to increased intrapelvic and intratubular pressure and may also be partly due to a nerve reflex from the ureter.

2. The demonstration of continued urine secretion with resorption of some of the constituents would substantiate the theory of a vital property of the cells of the uriniferous tubule.

3. The repression of urine and the resorption of some of the constituents of the urine may aid in protecting the kidney from an early hydronephrosis.

4. The experimental obstruction of the

ureter of a rabbit for sixty minutes results in the same changes in kidney function as occur in acute calculous obstruction.

5. Pain in acute calculous obstruction of the ureter is produced by the distended ureter, kidney pelvis and capsule.

6. In conducting an intravenous urographic examination, the study should be continued until late in the period of complete excretion of the contrast medium or much information will be missed.

7. In interpreting excretory urographic studies the roentgenologist must have an accurate clinical history with knowledge, also, of any instrumental procedures which may have immediately preceded his study.

8. The observation of the increase in the density of the kidney shadow in one or both kidneys during an excretory urographic study is very important in determining the presence of healthy renal tissue.

9. The employment of excretory urography may be an important differential diagnostic point in the frequently encountered obscure case of right lower abdominal pain where the diagnosis rests between the possibilities of appendicitis and ureteral calculus.

REFERENCES

1. Braasch, W. F. Intravenous urography. Am. J. Roentgenol. & Rad. Therapy, 1931, *25*, 196–206.
2. Dourmashkin, R. L. The value of intravenous pyelography in the management of ureteral calculi. *J. Urol.*, 1932, *27*, 637–658.
3. Howell, W. H. A Text-Pook of Physiology. Eleventh edition. W. B. Saunders Company, Philadelphia, 1930.
4. Macleod, J. J. R., and others. Physiology and Biochemistry in Modern Medicine. Sixth edition. C. V. Mosby Company, St. Louis, 1930.
4. McCaughan, J. M. The effect of renal denervation on the pressure of urine in the renal pelvis. *J. Urol.*, 1932, *27*, 659–665.
6. Richards, A. N. Methods and results of direct investigations of the function of the kidney. The Beaumont Foundation Lectures, Wayne County Medical Society, Detroit, Michigan. Williams and Wilkins, Baltimore, 1929.
7. Wesson, M. B., and Fulmer, C. C. Influence of ureteral stones on intravenous urograms. Am. J. Roentgenol. & Rad. Therapy, 1932, *28*, 27–33.
8. Wharton, L. R. The innervation of the ureter, with respect to denervation. *J. Urol.*, 1932, *28*, 639–673.

# ROENTGENOLOGICAL DIAGNOSIS OF APPENDICEAL ABSCESS*

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AMONG the cases of obscure and undiagnosed abdominal complaints that were sent to us during the last two years for roentgenological study, 7 could be very definitely diagnosed as appendiceal abscess. In each instance the diagnosis was confirmed at operation. This was such an unusual experience that we thought a report should be made of it.

A review of the literature reveals but few references to the roentgenological diagnosis of this condition. It was only after the recognition and establishment of certain criteria that we were able to more correctly diagnose the presence of an appendiceal abscess, and to differentiate it from other cecal lesions.

For example, all these patients presented themselves weeks or even months after their acute abdominal symptoms had subsided. Indeed, in several instances the patient failed to recall any acute abdominal illness. Very naturally, therefore, since in certain ones no mass could be felt such a thing as appendiceal abscess was not suspected. In all of them, however, the roentgen findings not only were uniform but were different from those cases where one has a right to suspect or to diagnose cancer, tuberculosis, or other usual lesion in the right lower quadrant.

To be explicit, these findings upon which we based our diagnosis of appendiceal abscess were as follows: (1) deformity or filling defect in caput of cecum; (2) displacement of ileum medially with constriction of terminal ileum; (3) hypermotility of cecum, as evidenced by diminution or absence of barium in the cecum after expulsion of the enema, barium still being present in the bowel proximal and distal to cecum; (4) no fixation of cecum when examined roentgenoscopically.

We believe the diagnosis can be made more definite if the barium enema is used, although Ritvo,[1] who reports 2 cases, gave the barium by mouth. Not that we object to the barium meal, but we find that in the presence of an inflammatory mass complete filling of the cecum is not usually obtainable because of the hypermotility of the cecum. Hence, no definite filling defect can be demonstrated. Furthermore, in order to visualize the ileum and cecum completely, one must force barium into the ileum through the ileocecal valve by overdistending the large bowel. This is easily accomplished with the enema, whereas good visualization is not obtained in this region with the barium meal.

## CASE REPORTS

CASE 1. I. S., male, married, aged sixty. Admitted to the Sinai Hospital on the service of Dr. Ullman, April 29, 1934, with complaint of pain in the lower right side of five weeks' duration. No associated nausea, vomiting, chills or fever. Two and a half weeks before admission, he began having sharp pain in the right lumbar region radiating around anteriorly to right thigh and knee. Some burning on urination. Appetite poor and was constipated. Latter treated with enemata. Lost 10 lb. since onset of present illness.

*Laboratory Examination.* Temperature, 98.2° F.; pulse, 90; respiration, 20. White blood count, 11,000; polymorphonuclears, 68 per cent; lymphocytes, 32 per cent; urine negative. *General examination* showed emphysema, arteriosclerosis, cardiovascular disease, benign prostatic hypertrophy and tenderness in the right lower quadrant, and a sense of increased resistance and sensation of fullness in that region. No definite mass palpable.

*Impression.* Ureteral calculus (right); subacute appendicitis.

*Roentgen Examination.* A plain film of the

[1] Ritvo, M. X-ray in diagnosis of appendiceal abscess. *Boston M. & S. J.*, 1927, *197*, 307–309.

* Read before the X-Ray Section of the Baltimore City Medical Society, February 20, 1934.

genitourinary tract was negative. A pyelogram of the right side was normal. The roentgenogram after barium enema showed deformity of caput of cecum; displacement of ileum medially with constriction of the terminal ileum; hypermotility of the cecum.

*Operative Findings.* A large retrocecal abscess was found containing a large amount of yellowish foul smelling pus; induration of right lateral iliac region.

Case II. L. M., male, single, aged twenty-seven. Admitted to the Sinai Hospital on August 5, 1933, on the service of Dr. Ney, with complaint of pain in abdomen, chiefly in right lower quadrant, of one week's duration. Beginning July 31, 1933, the patient had dull aching pains over the entire abdomen. No nausea, vomiting, chills or fever. The pains soon localized themselves to the lower abdomen, appearing in both the lower quadrants alternately, but being particularly severe on the right side. Pain persisted up to the time of admission. Anorexia since onset of illness.

*Laboratory Examination.* Temperature, 99.6° F.; pulse, 88; respiration, 22. White blood count, 8,100; polymorphonuclears, 66 per cent; lymphocytes, 28 per cent; mononuclears, 4 per cent; eosinophiles, 2 per cent; urine negative.

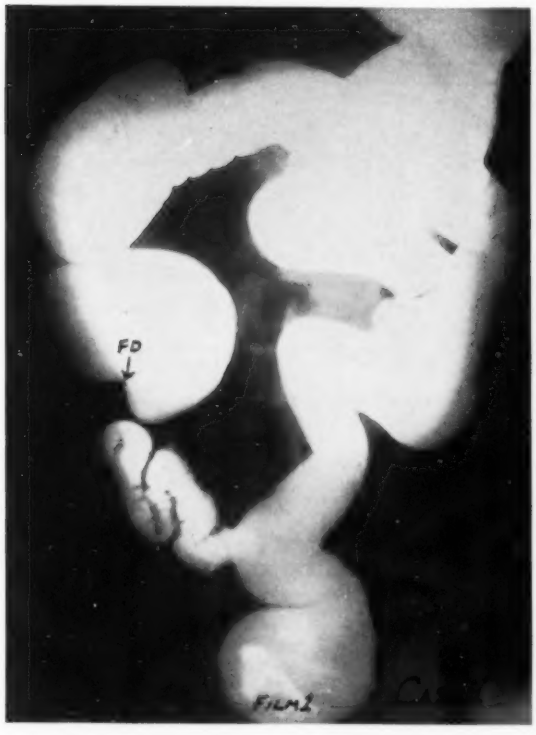


Fig. 1. Case I. *F.D.* Filling defect; before expulsion.

Fig. 2. Case I. After expulsion; showing hypermotility of cecum.

*General examination* showed a well-developed young man with a mass in the right lower quadrant about the level of the anterior superior iliac spine, measuring 5×7 cm. The mass was firm, not tender and movable. Did not shift with change of position of patient.

*Impression.* Appendiceal abscess; psoas abscess; tuberculosis of cecum.

*Roentgen examination* after barium enema showed deformity of caput of cecum; displacement of ileum medially with constriction of terminal ileum; hypermotility of cecum.

*Operative Findings.* Appendix found sloughed out and surrounded by small mass of necrotic tissue which on incision revealed presence of true pus.

Case III. J. C. N., male, married, aged fifty-two. Admitted to the Sinai Hospital on the service of Dr. Kern, June 2, 1933, with complaint of abdominal soreness, general malaise and anorexia of two weeks' duration. At onset of illness he was seized with severe sharp pains in the lower abdomen accompanied by nausea, but no vomiting. No chills or fever. Felt better lying down with "thighs drawn up." Re-

FIG. 3. Case II. *F.D.* Filling defect; before expulsion.

mained extremely constipated throughout illness and took cathartics daily with moderate success. Abdomen would distend at times and because of persistence of pain called in his physician who advised hospitalization.

*Laboratory Examination.* Temperature, 98.5° F.; pulse, 75; respiration, 24. White blood count, 6,100; polymorphonuclears, 56 per cent; lymphocytes, 41 per cent; mononuclears, 3 per cent; urine negative.

*General examination* essentially negative except for a mass palpable in right lower quadrant which was described as being small, irregularly shaped, firm in consistency and only slightly tender. The mass was fixed and lay just beneath McBurney's point.

*Impression.* Appendiceal abscess; tuberculosis of the cecum; malignancy of the cecum.

*Roentgen examination* after barium enema showed deformity of caput of cecum; displacement of ileum medially with constriction of terminal ileum; roentgenoscopically hypermotility of cecum; no fixation of cecum.

*Operative Findings.* Appendix was found to be lying in an abscess, the walls of which were limited by adhesions between cecum and terminal portion of ileum. Free pus was obtained on incision.

FIG. 4. Case II. After expulsion; showing hypermotility of cecum.

FIG. 5. Case III. *F.D.* Filling defect; before expulsion. Film after expulsion has been lost, but roentgenoscopic examination showed hypermotility of cecum.

Fig. 6. Case iv. *F.D.* Filling defect; before expulsion.

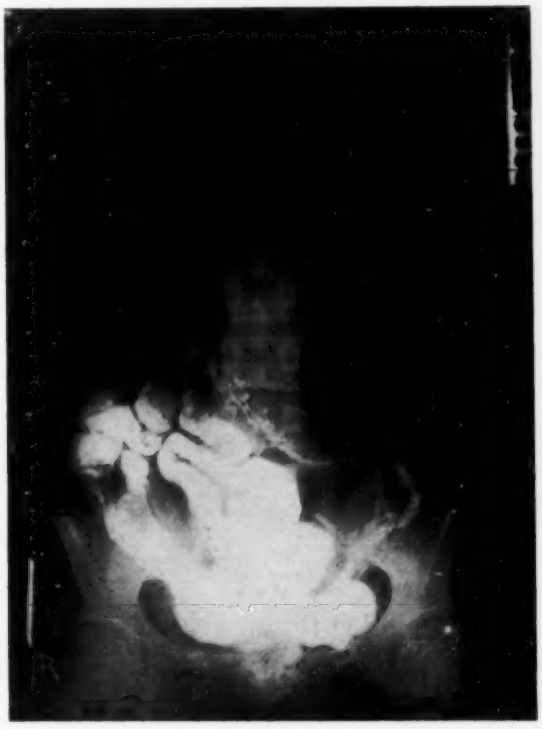

Fig. 7. Case iv. After expulsion; showing hypermotility of cecum.

Case iv. I. K., female, married, aged twenty-nine. Admitted to Sinai Hospital on the service of Dr. Louis Sachs, January 21, 1934, with complaint of dull pain in the right lower quadrant of two months' duration not sufficient to make her go to bed. On January 12, 1934, she had fairly severe and cramplike pains throughout the abdomen which came on simultaneously with her menstrual period. No nausea or vomiting, chills or apparent fever, and bowels moved regularly. The pains persisted in the abdomen, localizing in the right lower quadrant, and the patient stated that on sitting she had sensation of "needles being thrust into the lower right side." She felt somewhat better until January 18, when the pains in the right lower quadrant became more severe and she was forced to bed. Admitted to hospital three days later.

*Laboratory Examination.* Temperature, 99.4° F.; pulse, 96; respiration, 18. White blood count, 12,400; polymorphonuclears, 78 per cent; lymphocytes, 20 per cent; mononuclears, 2 per cent; urine negative.

*General examination* essentially negative except for mass palpable in the right lower quadrant which was somewhat tender and could be moved slightly downward and laterally appeared to be attached to the cecum. Pelvic examination corroborated these findings.

*Impression.* Appendiceal abscess; tuberculosis of cecum and malignancy of cecum.

*Roentgen examination* after barium enema showed deformity of caput of cecum; displacement of ileum medially with constriction of terminal ileum; hypermotility of cecum; no fixation of cecum.

*Operative Findings.* The terminal 3 inches of ileum were bound down to the cecum by inflammatory adhesions. The appendix was short, thickened and the base was concealed in an abscess cavity intimately connected to the terminal ileum. A few cubic centimeters of cloudy purulent fluid exuded on releasing adhesions.

# DUODENAL DIVERTICULOSIS*

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THE detection of 36 duodenal diverticula in a series of 2,250 consecutive roentgen gastrointestinal examinations, or 1.6 per cent, prompts this consideration of a lesion generally treated as of extremely infrequent occurrence by most writers on gastrointestinal disease.

## HISTORICAL

Since 1710 when Chomel reported the first case, which was probably not a true diverticulum, and 1761 when Morgagni described a true lesion, reference to this entity has been very occasional until quite recently. In 1913 Wilkie, in reporting 3 cases, noted that the total number recorded in the literature at that time numbered but 68.

Forssell and Key, in 1915, reported the first of these lesions diagnosed by means of the opaque meal and proved at operation. This work transferred the condition from the purely anatomic position it had previously occupied to the realm of medicine. Since that time, especially in the last decade, there have been numerous works dealing with the subject, and diagnosis by roentgenographic methods is now quite generally accepted, not to say expected.

## DEFINITION

Proper consideration of the subject necessitates a definition of true diverticulum which will permit the differentiation of this lesion from the false or acquired pouch. Since no definition is available, it is necessary to deduce just which diverticula are so regarded by those who have studied the subject. The consensus of opinion is that a sacculation of any portion of the duodenum, connected to the lumen of that structure by a neck containing no scar tissue, and having walls devoid of muscularis must be classified as true congenital diverticulum.

Congenital, in this definition, is used in the same sense that it is used in connection with herniae. That such a lesion may be a potential one and gradually develop and enlarge is borne out by the observations of Spriggs and Marxer who had the opportunity of making repeated examinations on a case in which this point was demonstrated.

## ETIOLOGY

There are many theories as to the etiology of these pouches but none have received complete acceptance. The presence of multiple diverticula in various portions of the gastrointestinal tract in the same patient appears to make the "back pressure" theory unsound. The fact that W. J. Mayo found colonic diverticulosis frequently proximal to obstructing lesions of the colon does not support this idea as much as would appear on the surface, since it offers no explanation as to why these lesions are found so often in patients without obstruction. Furthermore, the majority of all duodenal diverticula are found in relation to the pancreas, the additional support of which should make this area an infrequent site of occurrence if intraduodenal pressure is an important causative factor.

The theory that all diverticula have their origin in relation to a point of vascular puncture, while requiring further proof, appears to have considerable merit. Vessels may pierce the intestinal wall at any angle between 90 and 180 degrees. The incidence of this angle certainly has considerable bearing on the strength of the wall at that point. Odgers, in 1930, summarized and discussed the many etiologic theories previously advanced and also propounded one of his own which appears logical. He suggests that "at some time during the latter six months of foetal life, an exaggerated

* Read by title before the American Congress of Radiology, Chicago, Ill., Sept. 25–30, 1933.

downgrowth of Lieberkühn's crypts may reach lacunae in the muscular coat where this is pierced by the blood vessels: the perivascular sheaths will then provide an easy path for any further extension. From such weak spots pulsion diverticula may arise during adult life."

### FALSE DIVERTICULA

Probably the most common type of false diverticulum is formed through the perforation of a duodenal ulcer, with subsequent walling off of the accessory pocket by peritoneum, omentum and fibrous tissue. Another form occasionally noted consists of a dilatation of the ampulla of Vater. This latter condition should not be confused with true diverticula arising near the ampulla for this is a common site of occurrence. Ampullar dilatation can be ruled out by demonstration of the normal ampulla and absence of muscularis in the sac wall. Adhesive bands, the result of an inflammatory process involving adjacent tissues, may cause a sacculation of the duodenum which should not be confused with true diverticula.

Fig. 1. Case No. 19033. Diverticulum of second part of the duodenum.

Fig. 2. Case No. 19033. Same as Figure 1 at six hours. Multiple jejunal and ileal diverticula. All lesions proved at operation.

### CONCURRENT DIVERTICULA

The occurrence of diverticula of the various portions of the gastrointestinal tract in conjunction with similar duodenal lesions is more than occasional. In one patient of the series under consideration there were noted esophageal, gastric and colonic diverticula; in one (Figs. 1 and 2), multiple jejunal and ileal diverticula; in one, an esophageal diverticulum, and in two others diverticulosis of the colon. In none were multiple lesions of the duodenum observed, as has been reported by several writers.

### AGE INCIDENCE

Most writers have treated diverticulosis as a pathological condition limited to the later decades of life. The literature, however, makes note of diverticula found post mortem in fetuses as well as in children in the first decade. In this series, as is shown in Table 1, diverticulosis was observed in patients eighteen, twenty-six and twenty-seven years of age. We must consider that

TABLE I

DUODENAL DIVERTICULA

| Serial No. | Sex | Age | Pars Duod. | Additional X-Ray Gastrointestinal Diagnoses | Remarks |
|---|---|---|---|---|---|
| 12034 | M | 55 | 1 | None | No confirming data. Diverticulum seen at 6 hr. |
| 9677 | M | 54 | 2 | None | No confirming data. Diverticulum seen at 6 hr. |
| 12784 | M | 71 | 4 | Gastric ulcer—periduodenitis | No search at operation. |
| 15135 | F | 42 | 1 | Appendicitis chronic | No confirming data. |
| 14808 | M | 63 | 2 | Gastric ulcer (?) | Not found at operation. |
| 1160 | M | 59 | 2 | Chronic cholecystitis | No confirming data. |
| 14711 | F | 56 | 3 | Pyloric ulcer—chronic cholecystitis | No search at operation. |
| 3732 | F | 43 | 1 | None | Not found at operation. |
| 9742 | F | 27 | 2 | Cholecystitis chronic | Diverticulum seen at 6 hr. No search at operation. |
| 10044 | M | 18 | 2 | Duodenal obstruction | No confirming data. |
| 21893 | F | 54 | 2 | Cholecystitis chronic | No confirming data. |
| 13296 | F | 41 | 3 | Cholecystitis chronic—appendicitis chronic | No search at operation. |
| 21645 | M | 67 | 4 | None | No confirming data. Diverticulum seen at 6 hr. |
| 21762 | M | 38 | 2 | None | No confirming data. Diverticulum seen at 6 hr. |
| 21801 | F | 63 | 1 | Carcinoma of stomach | No confirming data. |
| 14343 | F | 58 | 2 | Esophageal diverticulum—chronic cholecystitis | No confirming data. |
| 11767 | F | 57 | 2 | Diaphragmatic hernia—chronic cholecystitis | Diverticulum seen at 6 hr. Found at operation. |
| 1575 | F | 66 | 3 | Cholecystitis chronic | No confirming data. Diverticulum seen only at 6 hr. |
| 16949 | F | 56 | 2 | Chronic cholecystitis-chronic colitis | No confirming data. |
| 11406 | M | 67 | 3 | None | Diverticulum seen at 6 and 24 hr. Found at operation. |
| 11030 | F | 49 | 3 | None | No confirming data. |
| 1078 | M | 53 | 1 | None | No confirming data. |
| 22147 | F | 31 | 4 | None | No confirming data. Seen only at 6 hr. |
| 30611 | F | 35 | 2 | Chronic cholecystitis | No confirming data. |
| 22949 | M | 59 | 4 | Duodenal ulcer | Diverticulum seen only at 6 hr. Found at operation. |
| 32298 | M | 66 | 1 | Duodenal ulcer | Not found at operation. Found at autopsy. |
| 32665 | F | 70 | 3 | Diverticulum of stomach, esophagus and colon | Found at autopsy. Seen also at 6 hr. |
| 32683 | F | 44 | 2 | None | No confirming data. |
| 33707 | F | 52 | 4 | Chronic cholecystitis | No confirming data. |
| 21825 | M | 52 | 1 | Chronic cholecystitis | No confirming data. |
| 19033 | M | 46 | 2 | Diverticulosis of jejunum and ileum | Diverticulum seen at 6 hr. Found at operation. |
| 32877 | M | 62 | 2 | Carcinoma stomach. Diverticulosis of colon | No search at operation. |
| 34450 | M | 53 | 3 | Diverticulosis of sigmoid and colon | No search at operation. |
| 32809 | M | 42 | 1 | Diverticulitis of first portion of duodenum | No search at operation. |
| 24556 | F | 26 | 2 | Diverticulitis of entire duodenum | No confirming data. |
| 16673 | M | 58 | 4 | Chronic cholecystitis. Partial obstruction | No search at operation. |

roentgen examinations of the gastrointestinal tract are made much more frequently after the third decade, which fact probably has considerable bearing on the number of diverticula found in each ten year period. As a result, there is a discrepancy between the relative and actual frequencies. It is not desired, however, to belittle the great part played by the ordinary degenerative processes which accompany the passage of years and permit potential and small diverticula to enlarge to a diagnosable size.

### SEX INCIDENCE

Diverticulosis has been noted by most authors as occurring most frequently in women. In this series, lesions were borne in equal numbers by both sexes but the relative and actual frequency values are at variance due to the preponderance of female patients examined. The ratio in this series of gastrointestinal examinations was 3 females to 2 males, which figures are representative of the average roentgen laboratory.

### ASSOCIATED PATHOLOGY

Diverticula are frequently found in the presence of other gastrointestinal pathological changes by roentgen examination. The patient with this lesion presents a diagnostic problem since there is no symptom-complex characteristic of duodenal diverticulosis. The symptoms may suggest any type of gastrointestinal lesion or the pouch may be silent and give rise to no symptoms. The improper gastrointestinal function which prompted the roentgenographic examination may be cleared up by removal of an offending appendix, gallbladder or other pathological finding without any attack on the diverticulum. In other words, the diverticulum is often an incidental symptomless finding.

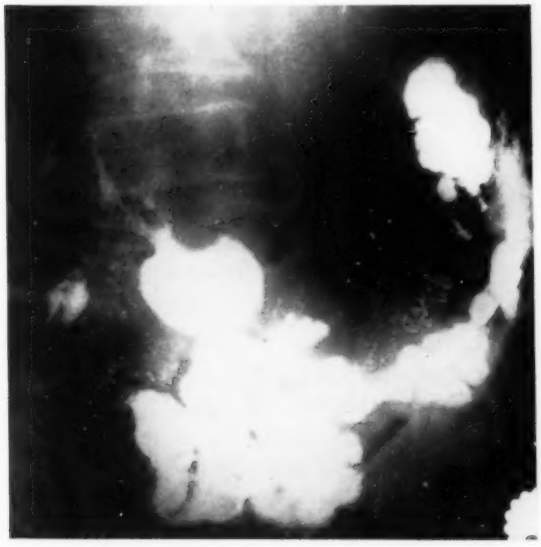

Fig. 3. Case No. 11406. Surgeon unable to locate this diverticulum of third portion of the duodenum until peritoneum was opened posteriorly.

Fig. 4. Case No. 32809. Diverticulitis of the first portion of the duodenum. Proved at operation.

Clinical judgment must be correlated with roentgen findings in order that a patient be given proper advice as to the correct therapeutic procedure. The incidence of other lesions in this series is given in Table 1.

### TECHNIQUE

In every examination of the gastrointestinal tract, regardless of sex or age, every effort must be exerted to rule out diverticulosis. Case has given in detail his technique, which includes compression at the duodenojejunal junction while massaging the gastric contents toward the pylorus. This maneuver is valuable when possible.

Roentgenoscopic examination of the patient in the erect, supine and prone positions, with oblique variations of all three, is essential in a conscientious effort to demonstrate these lesions. Careful palpation and compression during the examination are indispensable, for frequently a diverticulum may be visualized in only one position.

The six hour examination is important, as in 3 cases of this series the pouch was observed only at this time, having previously escaped detection. The sac may remain filled at the twenty-four hour examination and reports indicate an occasional diverticulum retaining barium after seventy-two hours.

### LOCATION

While the majority of all duodenal diverticula are located in relation to the pancreas, they may be observed on the anterior, posterior or lateral walls of any portion of this structure as well. The localization of the lesions in this series is also shown in Table 1.

Absolute precision as to the location of point of origin of the sac is of utmost importance and it is not sufficient to inform the surgeon that there is a diverticulum present. The roentgenologist is obliged to note the exact site, as the actual anatomical identification at operation may be quite difficult. In this regard Wilkie, in 1913, speaking of autopsy specimens declared: "In the literature there are records of only sixty-eight cases, but no deductions can be drawn from this, as such diverticula are very easily overlooked unless a special watch be kept for them."

### SURGICAL DIFFICULTIES

In view of the difficulties of identification, failure of the surgeon to locate the lesion at the time of operation does not disprove the diagnosis. The necessary extensive surgical procedures sometimes involved in locating a previously reported pouch is shown by the following extract from the surgical report of Case No. 11406 (Fig. 3): "Very careful exploration of the duodenum without opening the peritoneum did not demonstrate the diverticulum. The peritoneum was then opened so that three of the divisions of the duodenum could be visualized and palpated. At the junction of the second and third portions of the duodenum the diverticulum was demonstrated. The opening, which was about 1 cm. wide, came from the dependent portion of the gut."

Another instance in this series in which the surgical report failed to accurately describe pathological findings is seen in Case No. 32298 (Fig. 4). This operative report says: " . . . diverticulum of the duodenum immediately distal to the pyloric sphincter. On the superio-anterior edge of this there is an induration which is probably an ulcer." With this is quoted in contrast the autopsy report on the patient one week later, which says: " . . . the stomach is thoroughly explored as well as the duodenum and no evidence of cancer or ulcer of either can be found, but there is a diverticulum of the first portion of the duodenum 2 cm. from the pyloric sphincter on the inferior aspect pushing out 2 cm. from the lumen of the bowel and being 1.5 cm. in diameter at its mouth. . . ."

### ANATOMICAL FINDINGS

Thirty-six duodenal diverticula are herewith reported, having been detected in a series of 2,250 consecutive examinations of the gastrointestinal tract by oral barium administration. Fifteen of these were anatomically checked; 13 by laparotomy, one by autopsy after laparotomy and one by post-mortem examination following death from another cause.

Of the 15 cases checked, in 7 instances the surgeon made no reference to diverticulosis in his report of findings and procedures. In 3, diverticula were looked for and not found. Diverticula were found in 5 patients. One diverticulum (Fig. 4) showed marked inflammatory involvement and should be classified as a case of diverticulitis, as was indicated by the surgical record.

Thus we note that of 15 cases in which there was an exploration of the abdomen the surgeon did not attempt to locate the diverticulum in 7 instances as other pathological findings were considered the cause of symptoms. In 8 cases where an effort was made to locate the sac it was found in six.

### LOW DIAGNOSTIC PERCENTAGE

When it is considered that 16 per cent of the 37 duodeni studied by Grant, utilizing paraffin injection of the organ in cadavers, and 13.3 per cent of the 105 cases examined by Baldwin showed diverticula, we must appreciate the frequency of occurrence as well as the difficulty of demonstration of the lesions and the relative failure of roentgen diagnosis, in spite of all the care taken to demonstrate the lesions.

### REFERENCES


1. Albrecht, H. U. Duodenal diverticula. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1928, *38*, 605–619.
2. Albrecht, H. U. Clinical aspects of diverticulitis as a primary disease. *Deutsche med. Wchnschr.*, 1930, *56*, 1697–1699.
3. Andrews, E. W. Duodenal diverticula. *J. Am. M. Ass.*, 1921, *77*, 1309–1311.
4. Baur. Duodenal diverticula. *Wien. med. Wchnschr.*, 1912, *25*, 879.
5. Bernstein, A. Duodenal diverticula. *Med. Klin.*, 1928, *24*, 88–92.
6. Butler, P. F., and Ritvo, M. Diverticulum of duodenum. *Boston M. & S. J.*, 1925, *192*, 705–712.
7. Case, J. T. Roentgen observations on the duodenum with special reference to lesions beyond the first portion. Am. J. Roentgenol., 1916, *3*, 314–326.
8. Case, J. T. Diverticula of small intestine, other than Meckel's diverticulum. *J. Am. M. Ass.*, 1920, *75*, 1463–1470.
9. Cassar, A. Diverticulum of second portion of duodenum. *Radiology*, 1927, *9*, 915.
10. Cryderman, W. J. Duodenal diverticula. *Canad. M. Ass. J.*, 1927, *17*, 1455–1461.
11. Cullen, E. K. Diverticulum of first portion of duodenum. *Arch. Surg.*, 1921, *2*, 542–546.
12. Downes, W. A. Duodenal diverticula. *Ann. Surg.*, 1922, *76*, 43–51.
13. Editorial. Duodenal diverticula. *J. Am. M. Ass.*, 1921, *77*, 1341–1342.
14. Forssell, G., and Key, E. A diverticulum of pars descendens duodeni; diagnosis by x-rays, operative treatment. *Nord. med. Ark.*, 1915, 3. f., xv, afd ii, No. 2, 1–21.
15. Golob, M. Duodenal diverticulum; discussion of roentgen-ray findings and report of two cases of duodenal diverticula. Am. J. Roentgenol. & Rad. Therapy, 1928, *20*, 24–29.
16. Grant J. C. B. Duodenal diverticula. *J. Anat.*, 1922–1923, *57*, 357–359.
17. Hartung, A. Diverticula of duodenum. *Radiology*, 1925, *4*, 308–318.
18. Haudek, M. Diverticula of the duodenum. *Wien. klin. Wchnschr.*, 1924, *37*, 776–779.
19. Heacock, C. H. Diverticula of the duodenum. *South. M. J.*, 1929, *22*, 348–351.
20. Herbst, W. P. Diverticula of duodenum. *Minnesota Med.*, 1927, *10*, 364–368.
21. Herbst, W. P., and Hunt, V. C. False diverticulum of the duodenum containing gallstones, with cholecyst-diverticular fistula. *Surg. Clin. North America*, 1925, *5*, 807–811.
22. Jenkinson, E. L. Diverticula of small bowel. *Radiology*, 1929, *12*, 100–105.
23. Jones, W. M. Duodenal diverticulum with ulcer on opposite wall. *J. Am. M. Ass.*, 1922, *78*, 1706–1707.
24. Kampmeier, R. H. Duodenal diverticulum; report of case associated with definite symptoms. *Am. J. M. Sc.*, 1926, *172*, 590–594.
25. Kinard, K. W., and Vandel, D. T. Diverticulum of duodenum. *J. Missouri M. Ass.*, 1926, *23*, 430–434.
26. Larimore, J. W., and Graham, E. A. Diverticula and duplicature of the duodenum. *Surg., Gynec. & Obst.*, 1927, *45*, 257–265.
27. Lewis, D. A duodenal diverticulum. *J. Am. M. Ass.*, 1921, *76*, 783–784.
28. Lipschutz, E. W. Duodenal diverticulosis. *Am. J. M. Sc.*, 1925, *170*, 53–57.
29. Lucinian, J. H. Diverticulum of duodenum perforated into the pancreas. Am. J. Roentgenol. & Rad. Therapy, 1930, *24*, 684–685.
30. Lund, F. B. A case of diverticulitis of fourth part of duodenum. *New England J. Med.*, 1928, *198*, 986–988.
31. Maclean, N. J. Duodenal diverticulitis. *Ann. Surg.*, 1927, *85*, 73–83.
32. McKinney, J. T. Diverticula of the duodenum. *South. M. J.*, 1931, *24*, 753–757.
33. McQuay, R. W. Duodenal diverticula and their surgical treatment. *Ann. Surg.*, 1929, *89*, 36–47.
34. Monsarrat, K. W. Acute perforation of a duodenal diverticulum. *Brit. J. Surg.*, 1926–1927, *14*, 179–180.
35. Moore, E. C. Duodenal diverticula with report of a case. *Arch. Surg.*, 1920, *1*, 513–523.
36. Morrison, T. A., and Feldman, M. Carcinoma in duodenal diverticulum with consideration of duodenal tuberculosis. *Ann. Clin. Med.*, 1925, *4*, 403–414.

37. Murchison, D. R. Duodenal diverticulum with pyloric ulcer. *J. Am. M. Ass.*, 1920, *75*, 1329–1330.

38. Nagel, G. W. Unusual conditions in the duodenum and their significance. *Arch. Surg.*, 1925, *11*, 529–549.

39. Odgers, P. N. B. Duodenal diverticulosis. *Brit. J. Surg.*, 1930, *17*, 592–618.

40. Pendergrass, R. C. The roentgen diagnosis of duodenal diverticula. *Radiology*, 1931, *17*, 1216–1229.

41. Pendergrass, R. C. Duodenal diverticula, with report of two cases. *Am. J. Surg.*, 1928, *5*, 491–497.

42. Pendergrass, R. C. Roentgenologic examination of duodenum; value of oblique roentgenography. Am. J. Roentgenol. & Rad. Therapy, 1929, *22*, 355–359.

43. Penhallow, D. T. Case of duodenal diverticulum. *J. Am. M. Ass.*, 1923, *80*, 1372–1374.

44. Polgar, F. Roentgen diagnosis of duodenal diverticula. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1927, *35*, 1220–1230.

45. Roberts, D., and Cole, L. G. Diverticula of the duodenum. *Surg., Gynec. & Obst.*, 1920, *31*, 376.

46. Spriggs, E. I., and Marxer, O. A. Intestinal diverticula. *Brit. M. J.*, 1926, *1*, 130–134.

47. Thomson, J. W. Diverticulum of the stomach. *Brit. J. Surg.*, 1926–1927, *14*, 180–181.

48. Wilkie, D. P. D. Duodenal diverticula and duplicature of duodenal wall. *Edinb. M. J.*, 1913, *11*, 1219–1229.

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# MULTIPLE OSTEOCHONDROPATHY OF THE PHALANGES OF THE FINGERS*

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MULTIPLE osteochondropathy of the bases of the finger phalanges is, without doubt, one of the most interesting links in the chain of osteochondropathy. The subject was written on for the first time by Thiemann, in the year 1909, under the title of "Idiopathische Erkrankung der Epiphysenknorpel der Fingerphalangen." The author's case, which is very interesting from the clinical and roentgenological point of view, concerns a sixteen year old boy whose epiphyses of the finger phalanges and the great toe of both feet were affected. Thiemann thought that the nature of the disease infers a pathological process, especially in the epiphyseal cartilage, which begins in the later years of childhood and develops especially rapidly during the period of puberty.

Fourteen years later Fleischner reported a second case, putting the condition for the first time with the osteochondropathies. The third case of this disease was published by one of us (S.A.R.) in 1925. Then followed the reports of Kloiber, Laqua, Dessecker, Dahs, and Esau, each one describing only one case of multiple osteochondropathy of the phalanges.

Among these papers, the most valuable is the work of Dessecker, who was the first to confirm histologically the assumption of Fleischner and Reinberg that this disease belongs in the group of aseptic necrosis of bone.

Dahs' case is of more interest because the author had the opportunity to observe his patient for five years. Esau had his patient under observation during two and a half years.

The cases of Weil and Löhr stand apart from the others. In the first case, alterations typical of partly wedge-shaped osteochondropathy did not affect the epiphyseal bases of the middle phalanges but the extremities of the basal phalanges of the second, third and fourth fingers of both hands. In Löhr's case, within three months after a moderate freezing (2nd stage) many pathological changes appeared, mostly of a destructive character, in the epiphyseal ends of the terminal, the middle and basal phalanges.

Therefore since in the world literature we found only 7 typical cases of multiple osteochondropathy of the finger phalanges, this disease can be considered a very rare one. It is interesting to note that our personal material covers 6 cases. In brief they are as follows:

CASE 1.* P. J., aged seventeen, was referred for roentgen examination with the diagnosis of arthritis of unknown origin. Two years ago the patient injured the third finger of the left hand against the bed. Swelling and pain soon disappeared, but within two months they reappeared in the proximal interphalangeal joint of the same finger. Later the swelling appeared on the fourth finger of the left hand and on the third and fourth fingers of the right hand. Two and a half months later swelling also appeared on the fifth finger in the same joints. The swelling was accompanied by a sort of nagging pain in the morning and at work. Movements were limited; no difference of pain in the summer or winter. He never suffered from any other disease. Father died of pneumonia; mother alive. Of 5 brothers and 6 sisters, 2 brothers died in early childhood. The rest of the children are healthy. The patient lives on a farm and helps his brothers with the farming. Living conditions normal, neither drinks nor smokes.

The patient is of normal build and of medium height. The lymphatic glands are not enlarged.

* As already noted, this case was published in 1925,[11] but at the present time it is already traced to the full reverse development, i.e. almost eight years.

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FIG. 1. Case 1. P. J., male, aged seventeen.

Heart, lungs and other internal organs are apparently normal, as well as the nervous system. In the proximal interphalangeal joints of the third, fourth and fifth fingers of both hands, swelling is noticeable, being greater on the third finger of the left hand and on the fourth finger of the right hand. Skin normal. Active movements limited, flexion more than extension. The fifth fingers are less subject to swelling and limited movements. Pressure on the joint is painful.

Analysis of the blood showed: Hb, 85 per cent, red blood cells, 5,930,000.

Under three months of observation and treatment with 0.3 gr. of thyroidin daily, pains in the hand occasionally disappeared.

On the roentgenogram of both hands (Fig. 1), the epiphyses of the middle phalanx of the third and fourth fingers of both hands, especially the fourth finger of the right and the third finger of the left hand, are shortened in height and expanded in width. It appears that they are flattened between the expanded bases of the middle phalanx and the tips of the basal ones. They have no normal structure but present a collection of small, separated, sequestra-like shadows, along the bases of the middle phalanx, and alternating with the layers of rarefaction. The edges of the epiphyses are expanded far beyond the rims of phalangeal bases. The epiphyseal cartilages are irregular. The edges reach far into the roots of the phalanges. In places they are lost, but at the edges there is a little expansion. The bases of these phalanges are slightly loosened at the sides facing the cartilage and there are areas of rarefaction, alternating with spots of condensation. The joint spaces of the proximal interphalangeal joints of the third and fourth fingers of both hands seem to be shortened so much that, on the fourth finger of the right hand and the third finger of the left, the shadow of the epiphyses partly covers the shadow of the slightly expanded and deformed phalangeal heads. The epiphyses of the middle phalanges of the second and fifth fingers as well as the terminal phalanges on both hands, except the third fingers, where a synostosis can be detected, are slightly flattened, expanded and are more dense than normal. Only the epiphyses of the first fingers and the basal phalanges of both hands show no changes. Periostitis cannot be determined.

Ever since the patient was taken ill, seven years ago, we have repeatedly watched him. He is now twenty-five years old. From 1926 to 1929 he helped on the farm doing very light work. When doing hard work he suffered from a nagging pain, sometimes very strongly expressed, especially in the winter. At times, during changes of the weather he noticed an active pain.

In 1929 he had typhoid fever, which did not influence the bone condition. When touching the third and fourth fingers of both hands, one could feel as before, thickening of the extremities of epiphyses. In the proximal interphalangeal joints flexion was limited to a right angle and extension almost full. These symtoms are more noticeable on the fourth finger of the right hand and the third finger of the left. Some limitation of the movements could be noticed in the fifth fingers. The fourth fingers are slightly bent in a radial direction. The third finger of the left hand is shortened and is of the same length as the second and fourth fingers. The rest of the fingers are of normal length (Fig. 2).

On the roentgenogram (Fig. 3) (Jan. 26, 1933) of both hands, the following was noticed:

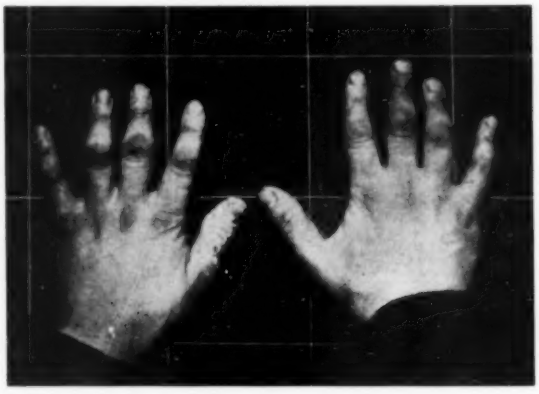

FIG. 2. Case 1.

the bases of the middle, and the heads of the main phalanges of the third and fourth fingers of both hands are considerably expanded, more so on the fourth finger of the right hand and the third finger of the left. In the spongiosa of the bases of the middle phalanges of the third and fourth fingers of the left hand could be seen a small cystic area of rarefaction. The heads of the basal phalanges of the fourth finger of the right hand and the third and fourth fingers of the left hand are sloped. The joint spaces of the above-mentioned joints of the rest of the fingers of both hands do not show any abnormality. All the epiphyseal cartilages have now disappeared, and synostosis of the epiphyses with the metaphyses is present.

Fig. 3. Case I. Roentgenogram seven years later.

Case II. A. Z., aged fifteen, was referred for roentgen examination with the diagnosis of tuberculosis of the hand. From the anamnesis we learned that nine months ago he noticed a swelling of the proximal interphalangeal joint on the third finger of the right hand.

During work he did not feel any pain. He did not pay any attention to the other fingers. He did a great deal of work on the farm. He has suffered from measles, whooping cough, pneumonia twice and ringworm, which was treated with roentgen rays. Family history irrelevant. Brothers (aged sixteen and twelve) are healthy. The first time that we consulted our patient was in September, 1924. At sight he was a healthy looking boy, of medium height and well nourished. In the proximal interphalangeal joints of the third and fourth fingers of both hands small swelling was seen. Skin normal. Active and passive movements not limited. Some pain under pressure and while shaking hands (Fig. 4).

Fig. 4. Case II. A. Z., male, aged fifteen.

On the roentgenogram (Fig. 5) (Sept. 1, 1924) the epiphyses of the middle phalanges of the second, third and fourth fingers of both hands, more especially on the third and fourth fingers, are flattened and more dense than normal. On the third and fourth fingers of both hands they are expanded in width so that their rims extend slightly beyond the side edges of the metaphysis of the phalanges; moreover they are slightly bent on the third fingers. The above-mentioned epiphyses of the third and fourth fingers of the right hand and the third finger of the left hand show transverse fractures, which are distinctly seen; on the third finger there are two similar fractures. The epiphyseal lines, metaphyses of these fingers, and also the joints and the epiphyseal cartilages are normal. On the next roentgenograms, after one, six and seven months, no substantial changes were seen, and on only the last roentgenogram could be seen the disappearing fracture line of the epiphyses of the fourth finger of the right hand and the third finger of the left.

In July, 1932 (after eight years), the patient now being twenty-eight, he was again examined. Now he complains of pain only while touching cold metal and with change in the weather. At times he feels a chilling of the

Fig. 5. Case II.

FIG. 6. Case II. Roentgenogram eight years later.

hands, especially the right. In 1929 he had scarlet fever, but without any complications referable to the hands.

At present he indulges in sport and plays the piano without any difficulty. In the proximal interphalangeal joints of the third and fourth fingers of both hands, moderate thickening is noticed. Flexion is slightly limited.

On the roentgenogram (Fig. 6) there are no pathological changes in the bones and joints of either hand, except an insignificant expansion of the bases of the second phalanx of the third finger of the right hand and compact islands in the metaphyses.

CASE III. V. B., aged nine, was treated for rickets before the roentgen examination. Birth normal (weight 6½ lb.). Has been growing thin and feeble. At the age of five she suffered from measles, chicken pox and whooping cough. At the age of six she fell ill with pneumonia and at seven with scarlet fever accompanied by bilateral otitis. At present she often suffers from tonsillitis. Her mother informs us that at the age of four the second and fifth fingers of the patient started to swell symmetrically. After one and a half years the fingers became deformed. At the beginning of her illness, especially during the winter, she suffered from slight pains, of rheumatoid character. Her mother, father and six year old sister are all healthy. Family history negative for tuberculosis or syphilis.

The patient is of medium height, normal build, and is undernourished. On the neck could be felt numerous, slightly enlarged glands. Thyroid gland not enlarged. Heart, lungs and other internal organs normal. The sella turcica is of normal size. The second and fifth fingers of both hands are deviated on the

FIG. 7. Case III. V. B., female, aged nine.

level of the proximal interphalangeal joints: the second fingers of both hands, in the radial direction, and the fifth fingers in the ulnar direction. On the above-mentioned fingers could be felt a slight swelling. Flexion is limited to right angle, and extension is not quite possible. Under action and pressure and also when being pushed along the axis of the fingers, no pain is registered. Skin normal (Fig. 7).

On the first roentgenogram (Fig. 8) (Dec. 6, 1931) of both hands the following was noted: The middle phalanges of the second finger of both hands are symmetrically shortened and the base enlarged. Its epiphyses are represented as a narrow, shortened more or less dense bent stripe, which is impressed into the bases of the enlarged metaphyses in such a way that the edges of the metaphysis surround the epiphysis and stand out more proximally. The epiphyseal zone is absent here. The joint spaces seem to be

FIG. 8. Case III.

twice as large as normal. The head of the basal phalanx is unchanged. In the epimetaphysis of the middle phalanx of the fifth finger, an analogous picture is presented. Here the joint space is also enlarged in the same way as the second finger. The epiphyses of the third and fourth fingers of both hands are slightly flattened, more dense and sharper on the edges than normal. The epiphysis of the terminal phalanx of the first finger of the left hand is quite synostosed; almost full synostosis is noticed on the same phalanx of the right hand.

On the roentgenogram taken a year after the first (Nov. 18, 1932), there is no further complication, the epiphyses of the basal phalanges on the third and fourth fingers of both hands take on a more normal view.

Case iv. A. Z., aged eighteen, unskilled laborer, was referred for roentgen examination with a diagnosis of polyarthritis. At work the patient complains of pain in the fourth finger of the right hand. About two months ago, there appeared, without any evident reason, a swelling. There was no injury. In cold weather the pain is sharper. He suffered from measles, scarlet fever and whooping cough. Parents healthy. Family history negative for tuberculosis and syphilis. He is of medium height, normal build and is moderately nourished. Lymphatic system, lungs, heart and other internal organs are normal. In the region of the proximal interphalangeal joint of the fourth finger of the right hand, there is a swelling, painful on pressure on the dorsal surface. Passive and active movements are limited; flexion more so than extension. The finger is slightly deflected in the radial direction. Skin normal.

On the roentgenogram* (Fig. 9) of the right hand (Dec. 14, 1929), the following was found: The epiphyses of the basal phalanges of the second, third and fourth fingers are slightly flattened and more dense than normal. The same epiphysis of the fourth finger is more flattened on the dorsal side and has fracture lines in two places: on the roentgenogram in the palm-up position, one-third of the epiphysis is represented on the radial side, in the profile view, on the dorsal surface. The joint space here is a little narrowed. The epiphyseal lines of the terminal basal phalanges are partly closed, the epiphyses normal.

Case v. P. K., aged twenty-three, electrician, was referred for roentgen examination with the diagnosis of polyarthritis. During a number of years of his childhood (patient does not remember exactly) he suffered now and then from slight pains while flexing the fingers of both hands. Recently the pains became more pronounced because he had to work at a machine. At work he feels uneasy because of limited flexion and extension of his fingers. In the winter this condition becomes worse.

Patient tall, strongly built and has an acromegaloid constitution. He has never suffered from any disease, and never complained of pain in the other organs. Married two years. His 3 brothers and 2 sisters are healthy. Parents alive and well. He denies syphilis or any other venereal disease. Born and raised in the country. He never protected his hands from the cold. The skin of his hands is of a dark red color with a purple tint, and with a normal sensitiveness. Under pressure pale finger prints can be seen on the skin, but as soon as the fingers are removed they become a darker purple. There is considerable spindle-shaped thickening of the proximal interphalangeal joints of the third finger of both hands. A slightly less thickening is noted on the same joints of the other fingers, with minimum alterations in the fifth and especially the first fingers. The metacarpophalangeal joints are normal. In the proximal interphalangeal joints, active and passive movements are limited, especially flexion. In their outward appearance both hands remind one of Dupuytren's con-

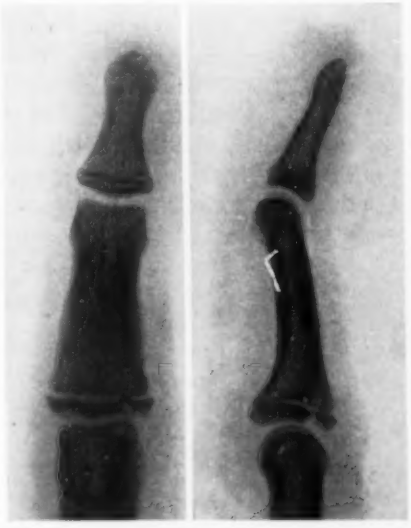

Fig. 9. Case iv. A. Z., male, aged eighteen.

* We are indebted to Dr. N. S. Markellov for the presentation of the roentgenogram in this case.

FIG. 10. Case v. P. K., male, aged twenty-three.

tractures. When the fingers are tapped or pressed in in the direction of the axis, no pain is noticed. The other joints are normal.

On the roentgenogram (Figs. 10 and 11) (May 13, 1927) of both hands, the following is shown: The bases of the middle phalanges and the heads of the basal phalanges of the third fingers of both hands are considerably expanded. The edges of the bases of the middle phalanges protrude far beyond the normal limits (especially on the right side of the third finger). This is very well shown in the profile view. Because of this, with the presence of contracture, the joint spaces cannot be determined on the film in the palm-up position. However, the joint space is of normal width, or only slightly narrowed. In the rest of the proximal interphalangeal joint region there is the same alteration as on the third fingers but much less pronounced. The epiphyseal zones are closed everywhere (synostosis). The rest of the skeleton shows no abnormalities.

CASE VI. A. S., aged twenty, carpenter, was referred for roentgen examination with the diagnosis of polyarthritis of unknown origin. The patient complains of considerable spindle-shaped thickening of the third fingers of both hands, more sharply defined on the right side. The swelling developed gradually between the ages of six and eight. When working out of doors in the winter he notices sharp pains, and also when grasping a tool so that sometimes he has to drop it; in the summer he has no pain at all. Now and then he notices a numbness and a tension. During the past years the swelling of both fingers has somewhat increased.

The patient is strongly built, with rough cyanotic hands. His movements in the swollen joints of the third finger are considerably limited. Under action there is a slight "scrunch."

On the roentgenograms (Figs. 12 and 13) of both hands, changes in the proximal interphalangeal joint region of the third finger on the left side almost fully coincide with the changes on the same joint of the right hand of the previous patient (Case v), but on right side of the third finger these alterations are more sharply defined. Strictly speaking, here we have the picture of a severe osteoarthrosis. The bases of the middle phalanx and the head of the basal phalanx are roughly expanded and deformed, with areas of rarefaction which extend from the joint side into the metaphysis of the middle and basal phalanges. The joint space is not outlined fully in either projection because of the superposition of the shadows of the edge of the middle phalanx on the head of the basal one. Here the head also seems to be pressed into the metaphysis of the middle phalanx as in the previous case. In the profile view in the palm-up position, the joint space is markedly expanded (0.5 cm.), and on the dorsal side it is narrowed. The epiphyseal lines of the hands are closed (synostosis).

FIG. 11. Case v.

Fig. 12. Case VI. A. S., male, aged twenty.

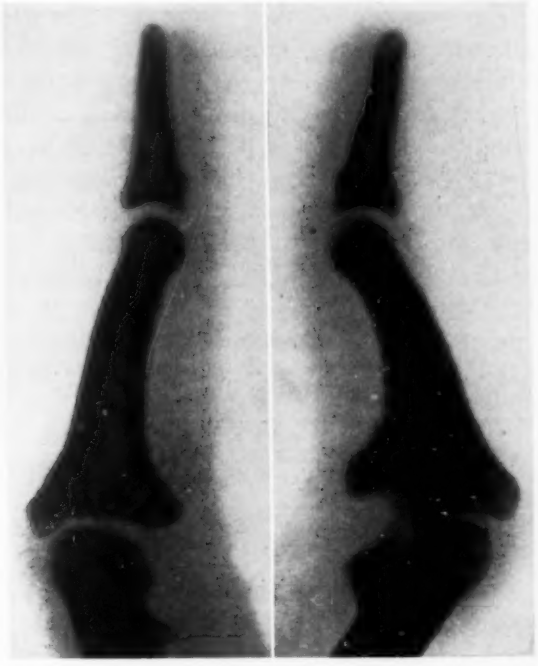

Fig. 13. Case VI.

Thus, our personal material gave us the possibility not only to study many cases of multiple osteochrondropathy of the phalanges, in their various clinical and anatomical-roentgenological phases, but owing to many years of observation of some cases, we were able to become acquainted with different stages of the disease, its course and result.

Our Case I, typical in all its symptoms, resembles Thiemann's case with multiple affections of the epiphyses of the middle finger phalanges of both hands. Case II is similar to Case I, with fractures of the epiphyseal bases. This case has been observed for eight years, that is, until the stage of completion of the reparative changes. Case III represents its peculiarities and is somehow atypical, probably because the disease began early, almost simultaneously with the beginning of ossification of the epiphyseal centers. Here the pathological process is limited only by the epiphyses of the second and fifth fingers of both hands, sparing the middle fingers. In Case IV the disease is shown mostly on the epiphysis of the middle phalanx of the fourth finger of the right hand, where roentgenologically a fracture was found. In the rest of the epiphyses, only slight alterations were shown. Finally, in Cases V and VI we have to deal, clinically and roentgenologically, with a secondary deforming osteoarthrosis similar to the final deforming joint processes, as a result of primary aseptic epiphyseo-necrosis in any other location.

Comparing our cases with those in the literature, we see that multiple osteochondropathy of the phalanges affects the male sex three times as often as the female. Of 13 that were affected, 10 were male and 3 were female.

As to the time of the beginning of the disease, all the material can be classified in the following:

| Age | Childhood | 3 yr. | 6–8 yr. | 12 yr. | 14 yr. | 15 yr. | 17 yr. | 18 yr. | 19 yr. |
|---|---|---|---|---|---|---|---|---|---|
| No. of Cases | 1 | 1 | 1 | 1 | 2 | 3 | 1 | 2 | 1 |

The greatest number of cases fall in the age preceding or corresponding to the period of puberty. It is necessary to emphasize that the majority of cases occur among those engaged in hard physical labor.

The third finger is injured as often and as markedly as the fourth.

| Right hand | Left hand |
|---|---|
| 3d finger in 10 cases | 3d finger in 10 cases |
| 4th finger in 7 cases | 3d finger in 6 cases |

Changes in the epiphyses of the second and fifth fingers usually followed the changes in the third and fourth fingers, with the exception of Case III. It is very seldom that changes are seen in the fifth finger. Up to now there has been no isolated location of the osteochondropathy in the fifth finger. Alterations of one single finger are described in 3 cases only (Esau, Dahs and our Case IV). In most of the cases the epiphyses of the middle phalanges are diseased, while the epiphyses of the terminal and basal phalanges are either completely spared or involved in the pathological process to an insignificant degree. Fractures of the epiphyses are noted in all cases, except in our 2 (Cases V and VI), where the patients have undergone for the first time roentgen examination in the later stages of the disease, when the aseptic necrosis, complicated by a pathological fracture, had been for a long time changed by the deforming process in the joints. Multiple fractures of several epiphyses are marked only in 4 cases, in the rest of the cases we have the injuring of only one or two of the epiphyseal discs. The simultaneous condition of the epiphysis of the terminal phalanges of the first toes with their visible fractures, together with the changes in the upper limbs, is described by Thiemann. In one of our cases (Case III) there appeared an early synostosis of the epiphyses of the terminal phalanges of the thumb.

The clinical picture of this disease is rather typical. The disease, as well as the majority of osteochondropathies, begins gradually, without any visible outward cause. The patient comes for medical aid more often because of the swelling and the limitation of movement in the joints. Seldom do they come because of pain.

The swellings in the proximal interphalangeal joints are often spindle-shaped in form, symmetrically on both hands, rough and compact to the touch, which correspond to the thickening of the base of the middle and head of the basal phalanges. Kloiber only has found a thickening of the joint capsule, Dahs mentions a little fluctuation. The deviations of the injured fingers can be seen very often (Fleischner's case, Dessecker's case, and our Cases II and III), whereas the second and fourth fingers deflect into the ulnar direction and the fourth and fifth fingers in the radial. The mechanism of this deformation can undoubtedly be explained by the function of the musc. flex. digit. siblim., which not only causes the finger aflexion, but partly adducts them to the middle finger. Sometimes this deviation is accompanied by a subluxation of the middle phalanx in the volar direction (Dessecker's case) or in the lateral direction (Case III).

The skin of the injured fingers, as a rule, remains normal; however, in Fleischner's case, a reddening of the epidermis was noticed, which was accompanied by a slight elevation of temperature, while in Case V, the skin was of a dark red color with a purple tinge. In most of the cases the movements of the swollen joints were limited, whereas the flexion suffered in a greater degree than extension. Moderate or insignificant pains were more of a rheumatoid character, and appeared only while the patient was working; more pronounced in the winter. Only in Kloiber's case was no pain observed. In the active stage of the disease, when there are great alterations in the epiphyses, palpation of the swollen joints is painful. In general, clinical phenomena depend more or less on the degree of the alterations: where there

is no fracture of the epiphyses, clinical symptoms are rather insignificant or absent altogether.

The state of the internal organs of patients suffering from osteochondropathy of the finger phalanges is quite normal. We, as well as other authors, cannot find any substantial endocrine or constitutional anomalies. The disease is of a local character. Analysis of the blood and urine does not in any way help in diagnosis. The biological and serological reactions, which are usually applied in clinics (Pirquet, Wassermann, etc.) are negative.

This disease, as well as other osteochondropathies, has been discovered by the roentgen ray. Only roentgenological examinations are able to differentiate this disease, and a correct diagnosis is possible only from the roentgenogram. Never yet has there been a case where the diagnosis of multiple osteochondropathy of the epiphyseal bases of the finger phalanges was based on clinical symptoms. The tentative diagnosis has been in this series in 2 cases tuberculosis; in 1 case syphilis; in 4 cases polyarthritis; and in 1 case rickets; the rest of the cases were referred for roentgen examination without a diagnosis.

The roentgenological picture of osteochondropathic injury of the phalanges is very characteristic. It expresses itself in the well-known general picture of the evolution of the osteochondropathy, which was studied principally by Axhausen.

This disease, in its development, passes in succession through the main stages of any osteochondropathy—stage of necrosis, pathological fracture, absorption, reparation and deforming osteoarthrosis. Therefore, it is necessary for us to emphasize only some of the peculiarities of the given localization of the osteochondropathic process. On the roentgenograms of the patient's hands, at the height of the disease, as in Thiemann's case and our Case 1, one can see on many epiphyses different stages of the development, beginning with the insignificant flattening and increasing intensity of the shadow of the epiphysis to the multiple fractures with sequestra-like shadows. Thiemann, Dahs, Kloiber, and others, justly indicate that the central part of the epiphyseal bases is destroyed before the other parts. We suppose that this can be explained by the influence of the muscular traction: the head of the basal phalanx presses hard, chiefly on the injured epiphysis and flattens and crushes it, destroying the sides of the epiphysis. In different cases, therefore, a seeming narrowing of the joint space depends on the fact that the head of the basal phalanx enters deeply into the destroyed central part of the epiphysis, the edges of which, hanging over the head, cover the joint space. This symptom is not only found in the initial stages (Thiemann's case and Case 1) but also in chronic cases (Case v). The epiphysis often presses into the metaphysis of the phalanx (Case III and Esau's case to some extent and the case of Fleischner). The metaphysis of the middle phalanx, similar to the metaphyseal end of the second metatarsal in the osteochondropathy of Köhler or to the neck of the femur in Legg-Calvé-Perthes' disease, thickens and shortens. The epiphyseal line loosens and acquires a winding path, alternately widens and shortens and sometimes it is completely lost. Above the epiphyseal line, in the metaphysis, there may appear areas of rarefaction (Fleischner's case and Case 1).

The roentgen picture depends greatly on the extent of the necrosis. With total necrosis of all the epiphysis, the intensity of its shadow increases, the structure is lost and the epiphyseal disc flattens and widens. With partial necrosis, the changes are either not sharply defined or involve only a part of the epiphysis.

The pathological fracture usually cuts off in one or several planes. A fragment of the epiphyseal disc is well seen from the left and right side of the axis of the finger on the roentgenogram in volar position or near to the dorsal surface in the lateral film. The line of the fracture is open and the bone fragments diverge, showing exactly the lateral axial displacement.

The stages of resorption and reparation in this osteochondropathy correspond to the well-known picture in other osteochondropathies. In the final stage of the disease, when there develops a deforming osteoarthrosis, this localization does not represent anything specific.

An entirely normal picture is determined by a roentgen examination of the remainder of the skeleton. The only exception is Thiemann's case. The sella turcica does not show any pathological changes, in particular.

The *differential diagnosis* of this disease is fully described by Thiemann, Fleischner, Dessecker, Laqua, and others, and represents no difficulties, if multiple symmetrical injury of the phalanges of both hands is present. Tuberculosis, syphilis, osteomyelitis, rickets, the disease of Möller-Barlow, gout, rheumatism, endocrine disturbances, in particular thyreotoxic polyarthritis, all these diseases need no consideration if the clinical and roentgenological symptoms are taken into account.

A great roentgenological resemblance to osteochondropathy of the phalanges may be found in the changes in the phalangeal ends in chondrodystrophia, but the absence of other systemic symptoms rejects this congenital disease of the skeleton. It is also necessary to have in mind that without the knowledge of the anamnesis and clinical data, the differential roentgen diagnosis between osteochondropathy and Kashin-Beck's disease is almost impossible. This endemic disease in the corresponding age (childhood or youth) shows a roentgen picture that recalls Case III. However, in Kashin-Beck's disease the epiphyseal cartilages of the basal phalanges are involved in the process comparatively early, as well as the first metacarpal bone, and besides the centers of ossification of the wrist undergo a specific deformation.

The distinguishing of the disease in only one finger or joint is far more difficult, especially in the presence of trauma. Kautz reports a case of an isolated fracture of the epiphysis of the middle phalanx of the fourth finger in a girl aged thirteen. The clinical picture of this case greatly resembled osteochondropathy. There has been a fracture of the epiphysis, similar to those described by us, but the absence of changes of the bone structure of the epiphysis and the rapid consolidation (after three months) with the strong development of the bone trabeculae corresponding to the fracture line, and also the full clinical and roentgenographic reparation a year after the beginning of the disease, speak against the osteochondropathy. The clinical picture of the chronic monarthritis of traumatic origin has much in common with that of osteochondropathy. Again, roentgenographic data help in the differentiation. But one must remember the possibility of the existence of double centers of ossification, which can be mistaken for a fracture.

The *course* of osteochondropathy of the epiphyseal bases of the finger phalanges, as well as of the other representatives of the osteochondropathies is chronic. In favorable cases the process ends with an entire restoration of the normal clinical and anatomic-roentgenological relations; sometimes, however, as for instance in the cases of Dahs, Esau and in our Case II, the swelling and the limitation of flexion is permanent. In our Cases V and VI, which represent examples of the outlet into serious deforming osteoarthrosis, from time to time considerable pain was noticed. Both of these cases began in early childhood.

What are the causes which determine the final result of this disease? Is it the onset in early childhood, is it the depth of necrosis, is it the character of the complication by pathological fracture or fractures, is it the peculiarities of the reparative process in each separate case, is it the medical measure—all this is not quite ascertained in all the osteochondropathies in general, and in the localization in the phalanges in particular. The cases which are followed by a considerable destruction of the enchondral discs may be complicated by the delay

of the growth of the phalanges in length and leave behind them, as in Case 1, an irreparable brachydactylia.

As to the *nature* of this bone disease and its *pathogenesis*, the whole clinical and roentgenological picture is so typical for the primary aseptic subchondral epiphyseo-necrosis, complicated by a pathological fracture, with the subsequent complicating reparative phenomena, that no one has expressed any serious argument against the including of this disease in the group of osteochondropathy. Now the necrosis is also proved histologically. Under microscopical examinations of the removed fragment of the epiphysis, Dessecker found, side by side, regions of entirely preserved bone tissue, clearly expressed necrotic areas. No signs of inflammation were noticed.

What are the nearest *causes of necrosis?* Up to now this question remains open. One thing, at any rate, has become evident, that is the untenability of the embolic theory of Axhausen. Changes, not only multiple and localized in definite epiphyses of definite phalanges, but bilateral and symmetrical—such a disease in no way can be conditioned by thrombus-embolus formation. At present, even concerning tuberculosis of the bone, the classical embolic theory must be considered not proved. In this respect, multiple osteochondropathy of the epiphyseal bases of the finger phalanges acquires a great principal meaning for all our knowledge of osteochondropathy in general, of what one of us (S.A.R.) already pointed out in 1925.

The causes of the disturbance of the arterial nutrition are undoubtedly various. This point of view is especially defended by Aschoff. The tendency to simplify this question, by explaining the necrosis by a traumatic injury only, is undoubtedly a mistake.

Our clinical observation gave us the right to consider as the most probable extrinsic cause of osteochondropathy of the finger phalanges the influence of frost. All our patients bear out this point, they being the inhabitants of the north, chiefly peasants and children who did not wear any gloves during work in the winter or while being out of doors for a long time. Probably for this reason, all the cases of osteochondropathy of the finger phalanges were collected, in a comparatively great number, by the Leningrad authors. The orthopedists and roentgenologists of Northern U.S.S.R. and Germany, and especially in Scandinavia, but not those of the southern countries, are working with the greatest material on osteochondropathy in general. Löhr also speaks in favor of this cause. His patient suffered from aseptic necrosis of the epiphyses of the phalanges, appearing immediately after the freezing of the fingers while riding a bicycle in the winter time. The pathological alterations appeared just in those places in the fingers that were not protected by gloves and were tightly pressed to the metal handle-bar.

Experimental investigations could have brought us nearer to the understanding of those functional and anatomical phenomena in the blood vessels, as a result of which the blood circulation in the epiphyseal tissue is destroyed and necrosis sets in.

The *treatment* of osteochondropathy of the epiphyseal bases of the finger phalanges is by palliative, symptomatic and chiefly physiotherapeutic measures. In the period of the climax of the disease, hard physical work is contraindicated. Surgical interference has no curative effect. From the prophylactic point of view, it is necessary to beware of the danger that freezing of the hands may entail.

REFERENCES

1. Dahs, W. Zur Osteochondritis deformans juvenilis der Fingerphalangen. *Deutsche med. Wchnschr.*, 1930, *56*, 1439–1440.
2. Dessecker, C. Zur Epiphyseonekrose der Mittelphalangen beider Hände. *Deutsche Ztschr. f. Chir.*, 1930, *229*, 329–336.
3. Esau, P. Juvenile Epiphysenstörungen an den Fingern. *Röntgenpraxis*, 1930, *2*, 374.
4. Esau, P. Juvenile Epiphysenstörungen an den Fingern. Nachtrag. *Röntgenpraxis*, 1932, *4*, 544.

5. FLEISCHNER, F. Multiple Epiphysenstörungen an den Händen. Eine bisher unbekannte Lokalisation der Osteochondropathia juvenilis. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1923–1924, *31*, 206–209.
6. KAUTZ, F. Isolierte Epiphysenkernfraktur am Finger. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1923–1924, *31*, 49–51.
7. KLOIBER, H. Symmetrische Epiphysenerkrankung der Hände. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1926, *34*, 500–506.
8. KÖHLER, A. Grenzen des Normalen und Anfange der Pathologischen im Röntgenbilde. Fifth edition. Georg Thieme, Leipzig, 1928, p. 19.
9. LAQUA. Multiple Epiphysenstörungen an den Händen. *Beitr. z. klin. Chir.*, 1929, *145*, 670–672.
10. LÖHR, W. Die Verschiedenheit der Auswirkung gleichartiger bekannter Schäden auf den Knochen Jugendlicher und Erwachsener, gezeigt an Epiphysenstörungen nach Erfrierungen und bei der Hämophilie. *Zentralbl. f. Chir.*, 1930, *57*, 898–909.
11. REINBERG, S. A. The x-ray diagnosis of the osteochondropathies. Osteochondropathia phalangum multiplex. *Vestnik rentgen. i radiol.*, 1925, *3*, 218.
12. REINBERG, S. A. Clinical X-ray Diagnosis of Diseases of the Bone and Joints. Academical edition. Leningrad, 1929.
13. THIEMANN, H. Juvenile Epiphysenstörungen. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1909–1910, *14*, 79–87.

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# FURTHER DISCUSSION OF THE SATURATION METHOD OF ROENTGEN THERAPY IN DEEP-SEATED MALIGNANT DISEASE*

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THE "saturation method" implies that the tissue shall be irradiated to the limit of normal tissue tolerance (saturation) either by single or multiple doses, in the region of the malignant disease, and that this effect shall be maintained by additional continuous or fractional irradiation over a period long enough to destroy all of the malignant cells or to arrest their growth. It involves the practical application of all of the principles of radiation therapy which are now known.

The *principles* involved in "saturation therapy" date from the beginning of roentgen therapy, and were used by Freund, Holzknecht, and myself about thirty-five years ago. At that time, however, these principles were utilized without system and without any definitely calculated plan or dosage. We did, however, give our treatment in fractional doses and carried it to the limit of normal tissue tolerance, as determined by the development of a well-marked erythema. In those earliest days, we used unfiltered radiation and were not able either to measure or calculate our dosage.

At the present time, the actual practical application of the principles involved in the "saturation method" consist of the administration of measured divided doses of filtered rays over a period of several weeks and these are also the principles involved in the "Coutard method." The "saturation method" or the "Coutard method" might very properly be called "protracted fractional irradiation," as recommended by Schinz, or "prolonged irradiation," as recommended by Holthusen. The fact that nearly all good results in radiation therapy have been accomplished by the application of these principles and the fact that these principles are used by all leaders in radiation therapy is sufficient to prove that the principles involved are correct. Skill and judgment in their application still need refinement in order to accomplish the best results.

Coutard has recently made a very real contribution to this method of prolonged, divided, highly filtered irradiation, by applying these principles in the treatment of cancer of the pharynx and larynx. He has used divided doses over a period of from two to four weeks, giving treatment daily or even twice daily, using 2 millimeters of copper, and prolonging the individual applications over a period of from one to four hours, thus approaching somewhat the prolonged action of radium, giving approximately 25 per cent of an erythema dose at each treatment. In its practical application this differs very little from the technique used in the "saturation method," for when one utilizes the highly filtered radiation with 2 mm. of copper, it is generally impractical to give more than 25 to 40 per cent of an erythema dose at one seance. This high filtration had been previously recommended, especially by Werner and by Rapp. By the use of this high filtration, we have found that it is possible to give a very definite increase in the total dosage. Coutard has shown that, at least in the tissues of the neck, it is possible to carry this treatment to the extent of producing a second degree dermatitis externally and an epithelitis in the pharynx which is followed by complete desquamation. His total dosage amounts to from six to ten erythema doses.

I have found that it is not practical to give such high dosage over the abdomen or in some other parts of the body where there

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is great danger of a fat necrosis. In the tissues of the neck it is possible, because of the good circulation, to give a total of from six to ten erythema doses, but I believe that when one exceeds a total of three or four erythema doses over the abdomen in any one portal, even though there is no serious immediate dermatitis, there is great danger later of fat necrosis. Likewise, when treatment is given over the lungs, the heart, the intestines, the liver or the spleen, it is probably not safe to use such a large total dose of radiation. In other words, Coutard has found in the tissues of the neck a much higher "tolerance" or higher point of "saturation" than we have formerly estimated. This illustrates what I mean by increasing our skill and improving our judgment in the application of the "saturation method."

The "saturation method" as such was described first in the preliminary paper by Kingery, in 1920, but he has not made any subsequent report. He made use of this theory in the application of unfiltered radiation in the treatment of skin disease. He assumed that the tissues recovered from the irradiation effects most rapidly when they were most nearly "saturated" and that this rate of recovery followed a logarithmic curve. This curve for his type of irradiation covered a period of two weeks or the interval of time after which a full erythema dose may be repeated. Using unfiltered roentgen rays of the low voltage type (130 kv.), the curve was helpful in enabling the roentgenologist to either build up the "tolerance" dose by repeated small doses or enable him to supplement the full dose by subsequent doses which would bring the tissue effects up to "saturation" or the "tolerance" point.

In general, this curve which covered a period of two weeks indicated recovery of the effects on the tissues to the extent of 50 per cent during the first quarter of the interval, and a recovery of 75 per cent during the first half of the interval. Therefore, he found by clinical experience that it was practical to add a 50 per cent dose at the end of a quarter of the interval, or 75 per cent of an erythema dose additional irradiation at the end of half the interval, or a proportionate amount of dosage on any intervening day.

This idea appealed to me, but I realized that to be of practical value to those of us who would confine ourselves to roentgen therapy we must adapt the curves to filtered radiation, which Kingery had not done. I therefore followed his general plan and from my clinical experience, I had learned that when 130 kv. low voltage therapy is used one could repeat an erythema dose in three weeks when 2 mm. of aluminum was used as filter; in four weeks when 6 mm. was used, and in eight weeks with 200 kv. and 0.5 mm. copper filtration. I therefore adapted the "saturation curves" on this basis of interval as determined by my clinical experience. I used a quarter of this interval for the addition of a 50 per cent dose, and half of this interval for the addition of a 75 per cent dose, and graded the intervening days proportionately. I recommended in my original paper treatment daily or twice daily, when it could be given, but under all circumstances, the "saturation" dose was built up by fractional treatment as rapidly as possible.

In practical work these "saturation curves" have been of very definite value to me and to many of my colleagues throughout the world during these past fourteen years. It is quite natural that we should find at the end of fourteen years that some modification or improvement can be made in the practical application of these principles. The principles of fractional dosage and progressively increasing filtration have been developed through the efforts of many of our colleagues in radiology.

In 1914, Reichold conceived the idea of giving divided doses with the object of destroying the cells during mitosis, and he controlled his work with biopsies. This, in fact, was the "saturation method," as is indicated by his statement as follows: "At that time, I conceived the idea of giving a full dose at intervals, first, to destroy the

mitosis that had already formed, and then with following doses, destroy the succeeding mitotic cells as they formed."

De Nabias and Forestier also by means of biopsies counted the number of mitotic cells (karyokinetic index), and attempted to determine the rhythmic formation of these cells with the object of controlling the divided doses of the roentgen rays.

Pagenstecher, in 1914, also recommended a prolonged irradiation with highly filtered rays.

With the idea of approaching as nearly as possible the action of radium, Werner and Rapp, in 1921, used 3 mm. of zinc as filtration which is about equivalent to 3 mm. of copper, and they gave the treatment in divided doses.

The principles, therefore, of the "saturation" therapy have been used by these and most other leaders who have obtained good results in roentgen therapy, even though their method or technique was not spoken of as the "saturation method."

Regaud found from his investigations that there was a progressively greater differentiation in the effects on the normal tissue as compared with malignant tissue when the higher filtration of from 2 to 3 mm. of copper or zinc was used, and that, under these circumstances, there was more protection to the overlying skin or tissue, and yet a definitely destructive effect on the malignant tissue.

The improved effects are in my opinion not the result of the increased penetration or increased depth dose caused by the higher filtration but are due to the actual increase in biological effect, as recognized by Werner, who also found an improvement from the use of divided doses as compared with the single massive dose.

In general, during the application of radiation in the treatment of deep-seated malignant disease, we are limited by the skin tolerance and also by the tolerance of the other tissues in the neighborhood of the malignant disease. The main principles governing us in the treatment of malignant disease are the following: (1) The effects of the roentgen and radium rays consist of the direct destruction of the cancer cells. (2) In the destruction of the cancer tissue, the normal cells, including skin, connective tissue, blood vessels, and other essential organs, must be protected, and one is limited in the effect that can be produced upon the neighboring malignant disease by the "tolerance" dose or "saturation" dose which these normal tissues can stand. All cancer tissue could be destroyed by the roentgen or radium rays if one were not definitely limited by the injury to the normal tissues. Therefore, any technique involved in this treatment must take into consideration these two points, namely, the effect on the malignant tissue, and the effect on the normal tissue. It is now generally recognized that less relative effect is produced on the normal tissue by prolonging the dosage, and yet it is possible by prolonging such dosage to deliver sufficient total dosage into the cancer tissue to arrest the cancer cells during mitosis.

It has also been determined, especially by Martin, Quimby and Pack, that it requires from six to ten erythema doses to destroy cancer tissue. It has also been definitely proved that there is more destructive effect on cancer cells by a single massive dose than by doses that are divided, but it is also self-evident that it is impossible to give from six to ten erythema doses as one massive dose to the normal tissue without destructive and disastrous results. It is these facts that lead one to assume that the more quickly the "tolerance" or "saturation" dose can be delivered into the diseased tissue, the more effect will be shown on that diseased tissue. In practical work, this generally requires from a few days to a week or even ten days to reach the saturation point. It will be seen, therefore, that these principles correspond in every respect to those as applied by Coutard, in which he has proved the above points, by using from two to four weeks of daily treatment and keeping up the saturation effect in the tumor tissue by means of such divided doses.

In practice, it is my aim to deliver the estimated dosage required into the diseased area within a period of from two to four weeks. It is necessary to calculate the saturation value for each port of entry as the saturation value and total dosage in the tumor tissue itself. It is also advisable to utilize cross-firing methods as much as is possible, in all instances, directing the rays by the side of rather than through essential organs. This requires keen judgment and much skill, and cannot be merely assigned to a technician. Even after fourteen years, we have not definitely determined the best combination of dosage to be utilized according to these "saturation curves."

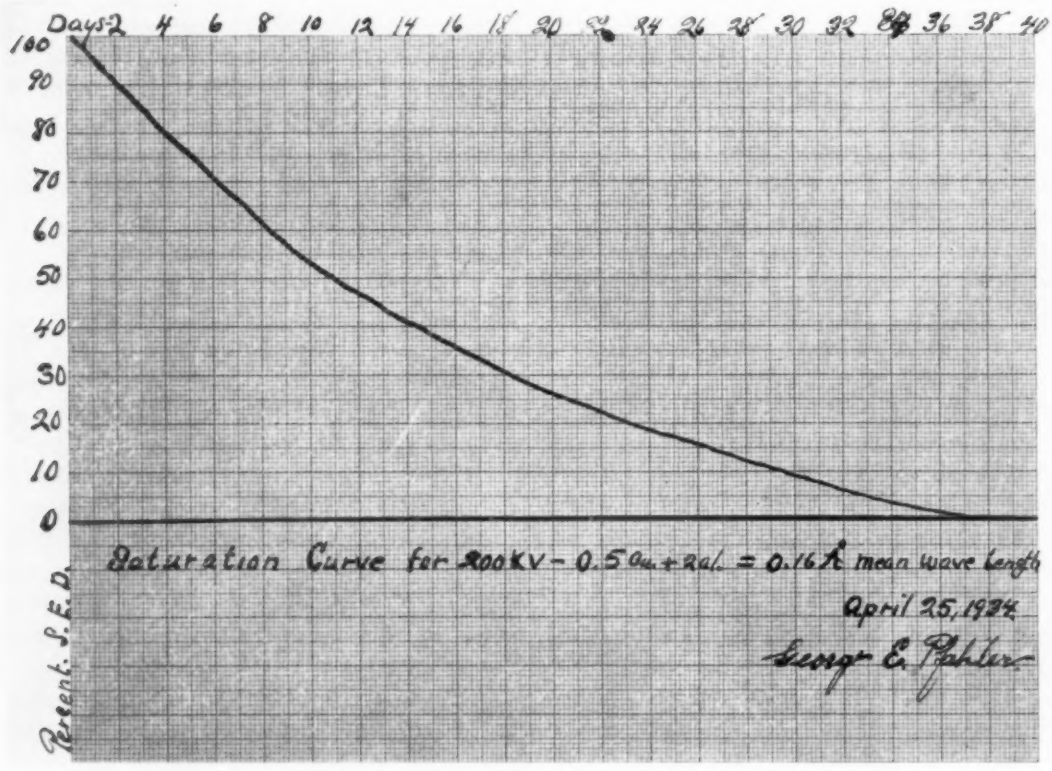


Chart I

Reisner, working with Holfelder, has made extensive studies on the erythema as affected by various techniques, and has reviewed the subject extensively. He found that a great variation occurs in the erythema dose as produced in different persons who were given the same carefully measured like quantity of rays. He refers to Miescher who found from ±40 to 50 per cent in the weaker erythemas, and ±20 per cent in the well-marked erythemas. Similar variations in the erythema dose were also found by Glocker, Hayer and Jüngling. The erythema dose varied from 300 r to 840 r with an average of 600 r when using 0.5 mm. of copper. To eliminate the variation due to the personal sensitivity to irradiation, Reisner, in his experiments, utilized six small areas of skin on the thigh of an individual for six different techniques, and applied the rays to each of these areas separately.

With regard to his studies of my "saturation curve," as published in 1925, he found that the additional dosage added for saturation at any one point can be definitely increased, and in reviewing Reisner's work, I have concluded that we are justified in increasing the saturation dosage at any given point or any given day by 20 per cent (Chart 1). We have been developing these "saturation curves" for 0.5 mm. copper

technique since 1922, or during the past fourteen years. Our own clinical impression has been that these saturation values have been too low. (The curves have been too high.) However, we have been able to reach a mild erythema by building up this dosage on this curve and have been able to retain a mild erythema. Reisner quotes Holfelder as follows: "We desire to find the erythema or interval of application of rays which will produce the most injury to the tumor, with an amount of irradiation that will be within the toleration of the surrounding normal tissue."

The determination of an erythema dose depends upon many factors, and therefore Reisner made use of an erythema meter. By such an instrument, Schwarz found that an effect could be recognized in the skin within two hours after giving a treatment. Schwarz also found that when using small fields, 1,200 r in one sitting would equal the same amount of erythema as 700 r when given on each of two succeeding days. Bachem learned that if a full dose were applied over three days the erythema was about one-third less. Reisner was able to recognize by means of the erythema meter, an effect in the skin even after a 10 per cent dose. The following table shows some of the observations that have been made by Reisner:

TABLE 5

EQUAL ERYTHEMA FOLLOWING AFTER DAILY IRRADIATION

| | | | | | |
|---|---|---|---|---|---|
| With | 10% | 27 times | equals | 270% | in 27 days |
| With | 20% | 12 times | equals | 240% | in 12 days |
| With | 30% | 7 times | equals | 210% | in 7 days |
| With | 40% | 4 times | equals | 160% | in 4 days |
| With | 50% | 3 times | equals | 150% | in 3 days |
| With | 65% | 2 times | equals | 130% | in 2 days |
| With | 100% | 1 times | equals | 100% | in 1 day |

TABLE 6

EQUAL ERYTHEMA FOLLOWING AFTER DAILY IRRADIATION

| | | | | | |
|---|---|---|---|---|---|
| With 2 times | 65% | | = | 130% | in 2 days |
| With 1 times | 70% | 1 times 50% | = | 120% | in 2 days |
| With 1 times | 80% | 1 times 53% | = | 115% | in 2 days |
| With 1 times | 90% | 1 times 20% | = | 110% | in 2 days |
| With 1 times | 100% | | = | 100% | in 1 day |

(The measurements were made in air without compression.)

By daily applications, a second grade dermatitis can be produced, as follows:

TABLE 8

DERMATITIS GRADE II, AFTER FOLLOWING DAILY IRRADIATION

| | | | | | |
|---|---|---|---|---|---|
| With | 20% each | 16 times | equals | 320% | in 16 days |
| With | 30% each | 9 times | equals | 270% | in 9 days |
| With | 40% each | 6 times | equals | 240% | in 6 days |
| With | 50% each | 4 times | equals | 200% | in 4 days |
| With | 60% each | 3 times | equals | 180% | in 3 days |
| With | 70% each | 2 times | equals | 140% | in 2 days |
| With | 120% each | 1 times | equals | 120% | in 1 day |

Some other very careful experimental investigations have been made with special reference to the "saturation curves," as I drew them for use in deep roentgen therapy and which were published by me in 1925. I am referring especially to the excellent work done by Juul, of Copenhagen, from whom I quote:

My own experiments were made on *mice with a transplantable adenocarcinoma*. In the first set of experiments, different groups of the animals were irradiated with the same dose of roentgen, either in one brief exposure or in 3 shorter ones with intervals of from 12 hours to 3 weeks. The results in every case showed that the effect was less, the longer the interval had been between the administrations of the partial doses. This would indicate that the influence of divided dosage is the same with regard to malignant tumors as with regard to other living tissues; namely, that the cumulation is incomplete.

At the same time, the effect on the skin of the animals—as judged by the epilation—was found to be considerably stronger from the single irradiation than when the dose was divided. But as the essential thing, from the therapeutical point of view, is the manner and proportion in which the irradiation reacts on *the normal and the neoplastic tissues, respectively*, it is not impossible that the therapeutical effect might nevertheless, in spite of this incomplete cumulation, be better from a divided dosage than from the single, full irradiation.

To investigate this, I irradiated two groups of mice, one in a single exposure, the other fractionally, with such doses that the skin effect on the two became the same; and then observed the effect in each case on the tumor. I also, at the same time, irradiated a third group according to the "saturation method" of Pfahler, giving first a rather strong dose and afterwards

several smaller ones, in such a manner that the skin effect was the same for all three groups.

*The effect on the tumors proved feeblest in the case of those that had been irradiated with one massive dose; somewhat stronger from the simply divided irradiation, and considerably stronger, again, from the dosage by Pfahler's method. This was shown both by the growth energy of the tumors, by the average lifetime of the animals who died with tumor, and by the number of those in whom the tumor disappeared.*

*If any conclusions can be drawn from these experiments on mice with transplanted tumors to the case of spontaneous tumors in man, it would be that in the treatment of the latter protracted irradiation should be preferred to massive doses, and the saturation method to simple dividing of the dose.*

In the application of the "saturation method," we must keep in mind the following points:

(1) The irradiation must be accurately measured, both as to surface and depth dose.

(2) The rays must be carefully directed into the diseased tissue, avoiding, so far as as is practical, the passage of these rays through important essential organs.

(3) We must estimate the distribution of the radiation within the tissues in connection with each application. For this purpose, the equipment as developed by Holfelder will be very useful.

(4) The cross-firing must be accurately done, and the total dosage passing through each portal of entry as well as the "saturation value" must be measured or calculated for each port of entry and for the tumor tissue irradiated.

(5) The normal tissues and the health of the general organism must be conserved so far as is possible. It is this fact especially that makes the "saturation curves" valuable, as compared with an ordinary set rule of application, or as compared with an indifferent application of divided doses, for in some cases, one can give a large dose at the beginning and thus reach saturation value in the tumor tissue early, while in others, especially when irradiating through the large blood vessels or heart, it is necessary to use many small doses (because of radiation sickness from large doses) in order to reach the required value. Likewise, there may be at any time a complication which interrupts the treatment, and these "saturation curves" then enable one to calculate more nearly the necessary dosage to be given supplementary than is possible in any other way except perhaps by the most expert.

(6) I believe that it is desirable to reach 100 per cent of an erythema dose in the tumor tissue as soon as is possible without producing radiation sickness, or without damaging any tissue. Generally speaking, it requires several days to a week in deep-seated disease.

## REFERENCES*


1. Alberti, W., and Politzer, G. Ueber des Einfluss der Röntgenstrahlen auf die Zellteilung. *Arch. f. mikr. Anat. u. Entwcklngsmechn.*, 1923, *100*, 83–109; 1924, *103*, 284–307.
2. Alberti, W., and Politzer, G. Das Zweckmässige Intervall bei mehrzeitiger Bestrahlung maligner Tumoren. *Strahlentherapie*, 1926, *21*, 535–549.
3. Arntzen, L., and Krebs, C. Investigation into the biological effect of filtered and unfiltered x-rays, as measured on peas. *Acta radiol.*, 1925, *4*, 5–31.
4. Bachem, A. Physical and biological observations about skin reactions. *Radiology*, 1927, *9*, 241–250.
5. Bayer, L. Versuch einer Erklärung des periodischen Ablaufs von Strahlen reaktionen. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1931, *44*, 522–526.
6. Béclère, A. Hauterythem und die sogenannte Erythemdosis in der Röntgentherapie. *Schweiz. med. Wchnschr.*, 1926, *56*, 361–366.
7. Björling, E. Eine biologische Einheit bei Dosierung der Röntgenstrahlen. *Strahlentherapie*, 1930, *36*, 751–777.
8. Bödecker, F. Beitrag zur Messmethodik in der Hauttherapie. *Strahlentherapie*, 1929, *32*, 777–781.
9. Borak, J. Die derzeitigen Bestrahlungsmethoden maligner Geschwülste vom Standpunkt der zeitlichen Dosenverteilung. *Strahlentherapie*, 1926, *21*, 380–388.


* For further references dealing with this subject, see former papers by Pfahler[43] and Pfahler and Widmann[46].

10. Borak, J. Die Hauttoleranz bei fraktionierter Bestrahlung nach Coutard. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1931, *44*, 258–259.
11. Brauer, A. Das Röntgenprimärerythem (Frühreaktion). *Deutsche med. Wchnschr.*, 1911, *37*, 538–541.
12. Braun, R. Vergleich der biologischen Wirkung von Röntgen- und Gammastrahlen. *Strahlentherapie*, 1930, *38*, 11–18.
13. Bumm, E., and Warnekros, K. Heilung tiefliegender Karzinome durch Röntgenbestrahlung von der Körperoberfläche aus. *München. med. Wchnschr.*, 1914, *61*, 1601–1605.
14. Coutard, H. Sur les délais d'apparition et d'évolution des réactions de la peau, et des muqueuses de la bouche et du pharynx, provoquées par les rayons X. *Compt. rend. Soc. de biol.*, 1922, *86*, 1140–1142.
14a. Coutard, H. Zusammenfassung der Grundlagen der röntgentherapeutischen Technik der tiefgelegenen Krebse. *Strahlentherapie*, 1930, *37*, 50–58.
15. Coutard, H., and Valat, A. Considérations sur le cancer de la bande et de la cavité ventriculaires du larynx. *Arch de l'inst. du radium*, 1928, *1*, 265.
16. David, O., and Gabriel, G. Die Kapillarmikroskopie des Röntgenerythems. *Strahlentherapie*, 1923, *15*, 125–145.
17. Dessauer, F., and Krüger. Die Nachbehandlung operierter Karzinome mit homogener Strahlung. *Berl. klin. Wchnschr.*, 1908, p. 536.
18. Dessauer, F. Bemerkungen zum Dosierungsproblem. *Strahlentherapie*, 1926, *23*, 579–593.
19. Determann, A., Jacobi, H., and Holthusen, H. Die Erythemwirkung verschiedener Strahlenqualitäten auf Grund von Messungen in Röntgeneinheiten mit dem Küstnerschen Eichstandgerät. *Strahlentherapie*, 1927, *26*, 472–483.
20. Dieterich, W. Fehlerquellen in der Apparatur und Dosimetrie und ihre praktische Auswertung. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1927, *36*, 182–183.
21. Erskine, A. W. Fewer variable factors in roentgen therapy. *Radiology*, 1930, *14*, 317–327.
22. Freund, L. Zur Geschichte der "Schwachbestrahlung." *Strahlentherapie*, 1927, *25*, 593–596.
23. Freund, L. Beiträge zur Radiotherapie. *Wien. med. Wchnschr.*, 1903, *53*, 853–857.
24. Freund, L. Die Bestrahlung- und chirurgische Behandlung maligner Neubildungen. *Deutsche med. Wchnschr.*, 1913, *39*, 2078–2083.
25. Freund, L. Die gegenwärtigen Methoden und Erfolge der Krebsbestrahlung mit verteilten Dosen. *Strahlentherapie*, 1930, *37*, 795–797.
26. Freund, L. Zur Indikation der Intensiv-Röntgentherapie. *Wien. klin. Wchnschr.*, 1922, *35*, 939.
27. Freund, L. Die Volldosen- und die fraktionierte Bestrahlungsmethode der Karzinome. *Acta radiol.*, 1931, *12*, 315–336.
28. Fürst, T. Untersuchungen über die Dosierung harter Röntgenstrahlung aus Fernfeldern bei der Behandlung des Collumcarcinoms. *Strahlentherapie*, 1929, *33*, 601; 1929, *34*, 340; 501.
29. Glocker, R., Hayer, E., and Jüngling, O. Ueber die biologische Wirkung verschiedener Röntgenstrahlenqualitäten bei Dosierung in R-Einheiten. *Strahlentherapie*, 1929, *32*, 1–38.
30. Gunsett, A., and Spack, Ch. La dosimétrie ionimétrique au centre anticancéreux de Strasbourg. *J. de radiol. et d'électrol.*, 1929, *13*, 199–208.
31. Gunsett, A., and Meyer, J. Variation de la radiosensibilité du tissu cutané humain et animal et de la glande génitale mâle du lapin en fonction de l'espacement du rayonnement. *Compt. rend. Soc. de biol.*, 1931, *107*, 58–60.
32. Hessmann, A. Massendosierung bei Tumoren. *Arch. f. klin. Chir.*, 1910–1911, *94*, 110–116.
33. Holthusen, H. Zur Geschichte der Langzeitbestrahlung. *Strahlentherapie*, 1931, *41*, 435–449.
34. Kottmaier, J. Die Dickfilterung in der Röntgentherapie. *Strahlentherapie*, 1923, *14*, 492–496.
35. Martin, H. E., Quimby, E. H., and Pack, G. T. Calculations of tissue dosage in radiation therapy. Am. J. Roentgenol. & Rad. Therapy, 1931, *25*, 490–506.
36. Miescher. Die Röntgenreaktion, der Haut, ein rhythmisches Phänomen. *Klin. Wchnschr.*, 1923, No. 42.
37. Morgan, J. D. Further observations on the treatment of malignant neoplasms by a fractional roentgen radiation technique. Am. J. Roentgenol. & Rad. Therapy, 1925, *13*, 244–246.
38. de Nabias and Forestier, J. Sur le traitement curiethérapique des épithéliomas malpighiens. *Compt. rend. Soc. de biol.*, 1923, *88*, 83–85.
39. Pack, G. T., and Quimby, E. H. The time-intensity factor in irradiation. Am. J. Roentgenol. & Rad. Therapy, 1932, *28*, 650–667.
40. Pagenstecher, A. Ueber Dauertherapie. *Strahlentherapie*, 1914, *5*, 401–406.
41. Perthes. Ueber den Einfluss der Röntgenstrahlen auf epitheliale Gewebe insbesondere auf das Carcinom. *Arch. f. klin. Chir.*, *71*, 978.
42. Pfahler, G. E. The saturation method in roentgentherapy, as applied to deep-seated malignant disease. *Brit. J. Radiol.*, 1926, *31*, 45–58.
43. Pfahler, G. E. Further observations on the saturation method in roentgen therapy as applied to deep-seated malignant disease. Am. J. Roentgenol. & Rad. Therapy, 1928, *20*, 233–241.

44. Pfahler, G. E. Radiation therapy in malignant disease with special reference to the saturation method. *Illinois M. J.*, 1929, *55*, 177–178.

45. Pfahler, G. E., and Widmann, B. P. Further observations on the use of the saturation method of radiation therapy in deep-seated malignant disease, with some statistics. *Radiology*, 1928, *11*, 181–190.

46. Pfahler, G. E., and Widmann, B. P. Statistical analysis of the radiation treatment of cancer of the breast on the basis of the saturation technique, 412 cases (1920–1928). Am. J. Roentgenol. & Rad. Therapy, 1929, *21*, 546–555.

47. Rapp, H. Ueber eine neue Dickfiltermethode für die Röntgentherapie. *München. med. Wchnschr.*, 1921, *68*, 73.

48. Regaud, Cl., and Nogier, Th. Die Einwirkung hoher X-Strahlen-Dosen, welche durch Filtration durch eine 3 und 4 mm dicke Aluminiumschicht gehärtet werden, auf die Haut und ihre Anwendung in der Röntgentherapie. *Strahlentherapie*, 1913, *2*, 733–787.

49. Reichold, A. Die Wirkung der Röntgenstrahlen auf die Mitosen im Karzinomgewebe und auf die Blautgefässe. *München. med. Wchnschr.*, 1921, *68*, 881.

50. Reisner, Alfred. "Pfahler saturation dosage" investigation. *Ergebn. d. med. Strahlenforschung.* Band VI. Thieme, Leipzig, 1934.

51. Schinz, H. R., and Slotopolsky, B. Experimenteller Beitrag zur Frage der Röntgenallergie. *Acta radiol.*, 1926, *7*, 365–404.

52. Schmidt, H. E. Zur Röntgenbehandlung tiefliegender Tumoren. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1909–1910, *14*, 134–136.

53. Schwarz, G. Ueber Verminderung und Vermehrung der Strahlenempfindlichkeit tierischer Gewebe in ihrer Bedeutung für die Radiotherapie. *München. med. Wchnschr.*, 1921, *68*, 766.

54. Schwarz, G. Die fortgesetzte Kleindosis und deren biologische Begründung. *Strahlentherapie*, 1925, *19*, 325–332.

55. Schwarz, G. Ueber die theoretischen und praktischen Grundlagen einer Lang-Schwach-Bestrahlungsmethode. *Strahlentherapie*, 1930, *37*, 709–718.

56. Werner, R. Neuere Behandlung von inoperablen Krebsgeschwülsten. *Chirurg*, 1929, *1*, 241–246.

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# THE RADIUM EMANATION TREATMENT OF VERNAL CATARRH*

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VERNAL catarrh, first described by Arlt in 1846 as conjunctivitis lymphatica, is a disease of the palpebral and bulbar conjunctiva occurring most frequently in young males and which is characterized by photophobia, itching of the eyes, and lacrymation. The cyclic aggravation of the symptoms in the spring and summer, with partial or complete subsidence of the symptoms (although the papillary lesions do not disappear) in the winter, is as characteristic of the disease as the lesions themselves.

The disease occurs in two forms, the palpebral and bulbar, but both forms are seldom seen in the same individual. In the palpebral form the lesions begin as a single papilla, or as a small group of papillae, and gradually spread until the entire conjunctival surface of the eyelids may be solidly covered. These papillae vary in size, but when fully developed are usually 3 to 4 mm. in elevation and 2 to 3 mm. in diameter. They are crowded closely together and flattened on the top from the lid pressure which gives them somewhat the appearance of pavement blocks. They never adhere to each other and they will always separate, showing narrow crevices, when the lid is bent back. They are much more frequent on the upper lids than on the lower, although they occur in both locations. These lesions are quite permanent in character and will remain well into adult life if not destroyed. The palpebral conjunctiva may also assume a velvety or milky appearance.

In the bulbar form the papillae are much modified and occur at the limbus. Here the lesions, resembling somewhat an arcus senilis, consist of conjunctival hyperplasias which push over the limbus from 1 to 3 mm. onto the surface of the cornea with an irregular, jagged margin. Persistent opacities of the cornea, secondary to corneal ulceration, may also be present.

The etiology and the exact pathology of the disease have not been determined. No microorganisms peculiar to it have been found. It is considered by some to be an ocular manifestation of allergy. The allergic investigations in this disease reveal that a large percentage of cases have a family history of allergic reaction. Also, over 50 per cent of the patients reveal an eosinophilia in the blood of over 4 per cent and the presence of eosinophiles in the eye smear. If vernal catarrh is a manifestation of allergy it is an allergy of the eczematous type rather than of the urticarial or the hay fever group because the pathology of hay fever consists of urticarial swellings which can be removed in a few seconds by adrenalin whereas the papillae of vernal catarrh are persistent. In this respect, then, vernal catarrh seems to be more nearly related to eczema, an allergy characterized by persistent inflammation. It has also been proposed that there may be an increase in the blood porphyrin associated with an increased sensitivity to light.

The papillae consist of thickened plaques of epithelium from which strands of epithelial cells extend into the stroma. The stroma is composed, for the most part, of lymphoid cells traversed by scanty, but rather vascular, bands of connective tissue fibers. It is probably this lymphoid, vascular stroma upon which the response of the lesions to irradiation is dependent. At times the stroma undergoes hyaline degeneration and it is this hyaline change in the superficial layers which gives rise to the velvety and milky appearance of the eyelids and

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which probably accounts for the resistance of some of the lesions to irradiation. Eosinophilic cells are often found in the conjunctival proliferations and are numerous in the conjunctival secretions.

Radium has long been used in the treatment of this disease and by many it is considered to be a specific. Guglianetti, in 1908, found that radium had a beneficial effect on the lesions of this disease and Davidson and Lawson, in 1908–1909, presented the first example of a complete cure of the disease.

In this clinic, radium, as the element with 0.5 mm. aluminum filtration, was formerly used in the treatment of this disease. Reactions following the use of the element were usually severe and were accompanied by persistent telangiectasis, temporary or permanent loss of the eyelashes, and, rarely, by corneal ulcer. The element was difficult to apply to the bulbar conjunctiva and lower lids. Its application was also accompanied by considerable danger to the operator because the application necessitated constant and intimate contact with the radium container and applicator, the applications lasting, at times, for fifteen minutes. The responsibility of the application could not be left to a technician and the applicator could not be held in place by adhesive tape. About 50 patients have been treated in this clinic with the radium element but the use of the radium element has been discontinued and these cases are not reported in this paper.

The use of radium emanation, because of these disadvantages, was instituted by one of us (E.P.P.) in 1927. The radium emanation and the applicators for its use were prepared by Mr. J. L. Weatherwax. Twenty-five patients have been treated by this method since 1927.

The applicator consists of a metal rod about 12 inches long to the end of which is fixed a flat plate about the size and shape of the eyelid. The radon is contained in glass capillary tubes, which are about 1 cm. in length, and these, in turn, are fixed to the flat plate by adhesive tape. The total initial quantity of radium emanation may vary from 50 to 250 mc. The application time with initial quantities of this order then becomes a matter of seconds rather than minutes. Inasmuch as the only filter is the thin glass capillary wall and a thickness or two of adhesive tape, the active principle of these applicators is almost entirely the beta rays. Great care should be exercised in the preparation and the handling of these applicators because of their high intensity in beta rays.

The application is made, after first anesthetizing the eye, by everting the eyelid and grasping it with eyelid forceps and applying the applicator, by direct contact, to the conjunctiva of the lids (or to the bulbar conjunctiva if this is the part to be treated) for a predetermined length of time. When the palpebral conjunctiva is treated, the bulbar conjunctiva and cornea are protected by a simple lead spoon laid over the cornea and reaching as far as the conjunctival fornix. As many areas as are necessary to cover the involved surface are treated at a single session. It is essential, in order to distribute the radiation uniformly, to know the position of the radium emanation tubes on the applicators.

A therapeutic dose is followed in a week or ten days by a reaction characterized by increased photophobia, conjunctival injection, increased lacrymation and itching, and occasionally by the formation of a whitish pseudomembrane on the conjunctiva and agglutination of the eyelids. An increase in the dose above that which therapeutically is necessary is accompanied by an increase in the severity of all of the reactions. A residual reaction, which appears after the course of the disease is interrupted and which is attributable to the emanation treatment, is a chronic conjunctivitis of a nonspecific form—the result of poor nutrition of the conjunctiva due to changes in the vascular supply. Atrophy of the conjunctiva with contraction of the cul-de-sac and narrowing of the fissures with limitation of lid movements may follow excessive doses. No patient in this

series, with the exception of one who was previously treated with radium element, lost his eyelashes. All reactions are increased in the spring and summer and for this reason patients should preferably be treated in the autumn or winter. If it is necessary to treat patients in the spring or summer the usual therapeutic dose should be reduced by one-fourth or one-third. Dark glasses should be worn during the period of reaction and if the reaction is particularly severe the patient may be kept in a darkened room. Out of doors, dark glasses with shields around the borders should be worn and dusty outdoor sports should be prohibited. If the patient is of the school age, he should be withdrawn from school during the period of reaction.

Twenty-one of the 25 patients in this series were males. All were unselected. The youngest was five years of age, the oldest thirty-five, and the average age was twelve years. Papillary involvement of the upper lids was present in all of the patients except one in which the disease was limited to the limbus. The lower lids were involved in 3 cases and there was a purulent discharge in 5 cases. The shortest duration of symptoms was six weeks, the longest fifteen years, and the average four years. The patients were followed for an average duration of two years. The smallest number of treatments required to effect a cure was one, the most seven, and the average 3.4. The average number of areas treated at each visit was three and the average interval between visits was two and a half months. The average dose per application was 6,500 mc-sec. to each area treated (for example, 200 mc. of the emanation held in contact application to the conjunctiva for $32\frac{1}{2}$ seconds) and the largest dose at a single application was 22,500 mc-sec., which was accompanied by a very severe reaction. The reactions were mild in 6 patients, moderate in 13, and severe in 5. The average number of treatments preceding a beneficial result was 2.5 and the best reaction and the greatest response were usually observed after the first treatment.

In an analysis of the results of this method of treatment it must be remembered that any method of treatment is subject to the criticism that the disease is self limited and that therefore spontaneous cures are frequent. The average duration of the disease in our patients when they were first seen was four years and it can be argued that the "emanation cures" were spontaneous. Most of the patients, however, were in a severe stage of the disease when they were first treated with radium emanation and most of them had been previously treated by other methods. The relation between the initial reaction and response and the subsequent relief from the symptoms of the disease was too close not to be significant.

Of the 25 patients treated by this method 8 were cured; 12 were markedly improved; 4 obtained a partial result, and 1 a poor result. The first two groups make a total of 80 per cent cures.

The one poor result was obtained in the patient whose photograph is shown in Figure 1. He was a police officer, aged thirty, who had had the disease for fifteen years. Of the 4 partial results, 1 was recurrent after radium treatment; 1 was of the bulbar variety, and 2 were unexplained. Of the 12 essentially free from the disease, 2 had a somewhat questionable cure. One was a female, aged thirty-four, who was left with a residual infection and discharge. The other had not been benefited by previous radium element treatment and after the radium emanation treatment a low grade streptococcal infection remained and some of the eyelashes were missing. This patient had manifestations of allergy elsewhere and he was the patient to whom the greatest single dose of radium emanation, that is, 22,500 mc-sec., had been given. In the responses observed in this series of patients, the objective and symptomatic improvement closely paralleled each other.

Many of the patients were interesting when considered individually. The response varies markedly in individual patients. One very severe case, a ten year old male with

symptoms for six years, had a complete regression after three treatments at intervals of one and a half months, while a very mild case, an eight year old male with symptoms for six weeks, showed a poor response after three treatments at intervals of two and a half months.

FIG. 1. A severe case of vernal conjunctivitis involving the conjunctiva of the upper eyelids. The patient is a police officer, aged thirty, who had had the disease for fifteen years. The upper eyelids are everted showing the papillae which are characteristic of the disease.

Three cases had a complete cure after one treatment of 4,500 mc-sec. at each application.

One severe case, a fifteen year old male, with symptoms for four years, had four treatments at three months' intervals. The objective signs had disappeared by the following summer but the symptoms did not disappear until the summer following that.

One patient developed papillae on his lower lids while undergoing treatment for papillae on his upper lids.

A female, aged nine, with symptoms of unknown duration, had intensive treatment—four 7,500 mc-sec. doses at one month intervals. The symptoms were markedly aggravated but the patient made a prompt recovery.

Corneal ulcers accompanied the disease in the most severe case (Fig. 1) but these were probably attributable to the disease rather than to the treatment.

Several cases were characterized by frequent recurrences.

## SUMMARY

Twenty-five cases of vernal catarrh have been treated since 1927 by the contact application of radium emanation contained in glass capillary tubes with 80 per cent cures.

There are no special indications for this method of treatment except the establishment of the diagnosis. Topical applications are accompanied only by the temporary relief of symptoms without anatomical change, while irradiation is accompanied not only by the relief of symptoms but by anatomical changes as well.

The average therapeutic dose is 6,500 mc-sec. applied to as many areas as necessary. More than twice this dose should not be exceeded at any one time. The intervals between treatments should be about two months. If the treatment is administered during the season of cyclic aggravation of symptoms the dose should be reduced to 4,000 mc–sec.

The reaction to this method of irradiation is characterized by an increase in the severity of all of the patient's symptoms, while the response is characterized by a gradual subsidence in the severity of the symptoms and a more gradual disappearance of the papillae.

The treatment is hazardous to both the patient and the operator because of the high intensity of beta radiation emitted through the thin glass capillary containers, and the applicators should be prepared and used only by those who are expert in the assembling and in the therapeutic application of radium products.

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# DIAGNOSIS AND TREATMENT OF MALIGNANT TUMORS OF THE NASAL SINUSES*

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IN a series of 60 consecutive cases of malignant disease of the nasal sinuses, 27 were males and 33 females. One-third of the patients were in the age group fifty to sixty years. The table below indicates the number in each decade of life.

| No. of Cases | Age Group years | No. of Cases | Age Group years |
|---|---|---|---|
| 2 | 0–10 | 12 | 40–50 |
| 3 | 10–20 | 21 | 50–60 |
| 6 | 20–30 | 7 | 60–70 |
| 4 | 30–40 | 5 | 70–80 |

In most instances, the diagnosis was made in the advanced stages. Either the patient had not presented himself for an early examination, or the family physician or dentist had not taken the patient's complaint seriously. There are wide variations in the clinical features as well as the histological types. The clinical picture may be nasal obstruction, with or without ulceration and bleeding, prominence of one cheek, protruding eye, tearing, bulging hard palate, and dull aching pains in the face. The histological types vary from the locally malignant papillary carcinoma to the very cellular and rapidly metastasizing forms. Unfortunately, the roentgen ray is of little value in the early recognition of malignant disease of the sinuses.

I should like to suggest exploratory operation be done more often, and that suspicious tissue be submitted to the pathologist. Once the diagnosis is made, and the type of growth determined, the method of treatment will be more easily outlined. In the very cellular radiosensitive types, such as lymphosarcoma, lymphoepithelioma and Schneiderian carcinoma, radical surgery is contraindicated. However, infection and osteomyelitis usually accompany and aggravate malignant disease. It is imperative that drainage be instituted. The orbit is often invaded by infection, and/or new growth, and enucleation of the eye or exenteration of the orbit becomes necessary.

A detailed report of all the cases cannot be given here, but in summary there are 15 patients who survived three years or more after surgery and radium were begun. The following are the results:

1 patient alive and well after 17 years
1 patient alive and well after 13 years
2 patients alive and well after 10 years
2 patients alive and well after 8 years
1 patient alive and well after 6 years
4 patients alive and well after 5 years
3 patients alive and well after 3 years
1 patient alive and well after 8 years but died suddenly of heart disease in January, 1935.

The following case histories illustrate the irradiation and surgical methods used in the treatment of this group of patients:

CASE 1. R. R., female, married, aged thirty-seven, was referred to me on March 19, 1925, by Dr. Henry H. Forbes, for treatment of recurrence of carcinoma of the right antrum. Patient had been operated on seven years previously by Dr. Forbes and radium applied by the late Dr. Janeway. When first seen by me there was a rather large recurrent mass in the ethmoid and posterior wall of the antrum, which bled easily. Biopsy revealed adenocarcinoma. Radium tubes were applied to the growth in the right antrum, giving approximately 4,000 mg-hr. in two treatments, March 20 and March 27, 1925. The recurrent growth disappeared and the patient has remained well up to this time. A dental obdurator has been made by Dr. A. J. Schwartz to fill the defect. I am greatly indebted to Dr. Schwartz for his constructive restoration of many defects, without which the end-results would have been poor, because of function and cosmetic appearance.

* Read before the Section of Otolaryngology, New York Academy of Medicine, May 15, 1935, and the Twentieth Annual Meeting, American Radium Society, Atlantic City, N. J., June 10–11, 1935.

CASE II. D. M., male, aged fifty-four, was referred to me by Dr. Richard W. Moriarity on June 21, 1930. The patient had always been well, except for occasional colds, until March, 1930, when a rather severe hemorrhage occurred on the left side of the nose, which was rather difficult to stop. After packing had been removed, a friable tumor mass was discovered. Biopsy revealed cellular carcinoma Grade II, Schneiderian origin. No radical operation was done, and the following radium treatments were given:

6/21/30—100 mg. 2–50 mg. tubes—20 hr.—2,000 mg-hr. Left ethmoid area
7/ 3/30—100 mg. 2–50 mg. tubes—20 hr.—2,000 mg-hr. Left ethmoid area
7/31/30—100 mg. 2–50 mg. tubes—20 hr.—2,000 mg-hr. Left ethmoid area

The condition gradually improved, and the growth subsided; however, secondary sinusitis was present and considerable inflammation persisted in the left side of face. On March 10, 1931, both antra were explored by a Caldwell-Luc operation by Dr. Faulkner, and no evidence of growth was seen or revealed by histological examination. The right antrum contained purulent discharge, and the left antrum showed thickened membrane. However, the patient's general condition did not improve, and after consultation, Dr. Quick removed the contents of the orbit, because of the pain and infection. The orbital plate showed osteomyelitis, but no growth was found in the orbit. The patient has now regained his normal weight, and there is no evidence of malignancy.

CASE III. T. N., female, married, aged fifty, referred by Dr. A. Lobell, of the late Dr. Mackenty's clinic, on July 8, 1930. The patient had been operated on for polypoid tissue on the right side of the nose ten weeks before admission to the Manhattan Eye, Ear and Throat Hospital, but no microscopic examination was made of the tissue removed. There was a rapid recurrence, and when first seen at the hospital the entire right nose was blocked with ulcerated tumor tissue. The right cheek was slightly bulging, and on pressure on the cheek it was noted that friable tumor tissue could be extruded from the right side of the nose. Microscopic examination of this papillary mass showed hyperplasia of the mucous membrane, and thickening of the epithelial layer, with marked desquamation. There was a definite limiting membrane with active mitosis of the tumor, as well as numerous thin-walled blood vessels. Edematous connective tissue was also present, and a diagnosis of papillary adenocarcinoma was made. The roentgen examination revealed destruction of outer and inner antral walls, but no involvement of the orbital plate. The ethmoid and sphenoid were also involved.

On August 1, 1930, a Caldwell-Luc operation was performed, and a portion of the growth was removed. Two 50 mg. radium tubes were applied to the right antrum, and one 50 mg. radium tube to the right ethmoid region for forty-eight hours. A week later one 50 mg. radium tube was applied to the right antrum for twenty-four hours, and on September 18, 1930, two 50 mg. radium tubes were applied to the right ethmoid and sphenoid regions for five hours. The total radium dosage amounted to 6,500 mg-hr.

There was a stormy convalescence following the operation and radium treatments. Tissue of the right cheek and temporal regions became infected with *Staphylococcus aureus* and *Streptococcus viridans*. Several incisions were made for drainage. During the three or four months following the radium treatments, large sequestra of bone were removed.

At the present time, five years after operation, there is no evidence of new growth. A large defect is present in the hard palate, and there is a partial ankylosis of the lower jaw, which may be accounted for by the contraction of the muscles on the right side of the face, the loss of bony structure, and the scar tissue, which resulted from the abscess formations in the soft tissue.

CASE IV. M. McG., female, aged fifty-three, referred by Dr. Lester M. Hubby, on February 18, 1927, for treatment of a large tumor mass involving the entire right side of the nose and nasal sinuses on that side. The condition had existed for eight months, and had gradually caused nasal obstruction, mucopurulent discharge and finally severe and frequent hemorrhages. Pain was not a symptom, and the general condition of the patient remained good. Examination of the nose revealed a large ulcerated mass filling the entire right nasal fossa.

The radium dosage consisted of 3,400 mg-hr. of interstitial irradiation in divided doses, using implants, tubes and needles. No radical opera-

tions were performed. The antral walls were destroyed by the growth, and radium was easily applied to the nasal cavities. Over a period of one year fragments of dead tumor tissue and sequestra of bone were removed. The floor of the antrum became eroded as well as the ethmoid region. The patient is now well for more than eight years.

Case v. C. B., male, aged twenty-four, a mechanic, was referred for postoperative radium treatment on May 29, 1922. Two years previous to operation the patient had a chronic nasal discharge with occasional bleeding from the right side. For six months there had been a failing of vision in the right eye. The blood Wassermann reaction was negative. The red blood count was 3,000,000, with a hemoglobin of 56 per cent.

On April 3, 1922, Dr. Duncan MacPherson removed, by a radical operation, the growth from the right side of the nose. The right maxillary antrum and ethmoid sinuses were involved, and the growth filled the right nasal cavity and extended into the nasopharynx. The pathologist's report was fibrosarcoma and stated that a local recurrence was to be expected.

On May 31, 1922, or approximately two months after operation, there was a recurrent tumor mass 2 cm. in diameter in the posterior nares. Four 5 mg. radium needles were inserted into the growth and allowed to remain for five hours. An external pack of 2,200 mg-hr. at a distance of 3 cm. was applied to the right side of the face and neck. Similar treatments were given in June, August, September, October, and November, 1922, and February, May and July, 1923. In all, 20,000 mg-hr. of radium was given. The patient has been observed at regular intervals for over ten years, and no evidence of recurrence has been noted.

Case vi. W. B., male, aged thirty-one, was referred by the late Dr. John E. Mackenty on September 4, 1925. Examination showed a rather anemic young man with a large ulcerated growth involving the right middle and superior turbinates and ethmoid regions. The antrum appeared clear and there were no nodes in the neck. Dr. Andrew A. Eggston reported the biopsy as lymphosarcoma. The radium treatments are as follows:

| | | | |
|---|---|---|---|
| 9/ 4/25 | 200 mg. (tubes) | 3 hr.—in right nostril | 600 mg-hr. |
| 9/11/25 | 100 mg. (tubes) | 3 hr.—in right nostril | 300 mg-hr. |
| 9/25/25 | 100 mg. (tubes) | 3 hr.—in right nostril | 300 mg-hr. |
| 10/ 9/25 | 100 mg. (tubes) | 3 hr.—in right nostril | 300 mg-hr. |
| 11/14/25 | 100 mg. (tubes) | 2 hr.—in right nostril | 200 mg-hr. |
| 11/21/25 | 200 mg. 3 cm. dist. | 20 hr.—external to cheek | 4,000 mg-hr. |
| 2/ 7/26 | 300 mg. 3 cm. dist. | 20 hr.—external to cheek | 6,000 mg-hr. |
| 6/12/26 | 150 mg. 3 cm. dist. | 16 hr.—external to cheek | 2,400 mg-hr. |

The patient is now well and has been free of the disease for ten years.

## SUMMARY

1. In cases of malignant disease of the nasal sinuses, a routine preoperative treatment using roentgen rays or radium packs appears to be indicated.

2. In the very cellular types, surgery is contraindicated, and may be unnecessary, as external irradiation should be sufficient to destroy the growth.

3. In the more resistant types, operation is indicated for drainage, and to make the maxillary antrum and other nasal sinuses more accessible for radium application.

4. Plastic surgery and dental procedures restore the defects to a remarkable degree.

5. If a five year period is taken, 12 patients, or 20 per cent, are clinically well, and if a three year period is taken, 15 patients, or 25 per cent, are clinically well by the combined methods of surgery and radium.

# FURTHER OBSERVATIONS ON THE USE OF UNFILTERED ROENTGEN RAYS FOR SUPERFICIAL CANCERS OF WIDE AND DEEP INVOLVEMENT*

*By* BERNARD P. WIDMANN, M.D.
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THE treatment of cancer of the skin has been uniformly successful with radium, roentgen rays and electrosurgical procedures. Good results have been obtained with a manifold variety of techniques. Unfiltered roentgen rays, with fractional doses and a wide range of intensities, have been employed universally since the discovery of roentgen rays with almost uniform success.

This is a tribute to the older radiologists because it demonstrates that they tempered skill and experience with clinical judgment. Dosage was an empirical procedure, and each radiologist had to know his own machine. Duplications were impossible because radiation intensities varied with roentgen-ray tubes, viz., variable glass wall thicknesses and focal points, lack of uniformity of degree of gas density or tube vacuum, inaccurate electrical meters and various systems of rectification, and particularly inaccurate spark gap measurements.

Progress in radiology has been immeasurably enhanced and commensurate with the refinements of modern apparatus and standardized physical equipment. Today there are facilities for physical measurements, thereby standardizing the physical factors involved and radiation output of radiotherapeutic apparatus in any laboratory, with mathematical precision.

As a result of this standardization, radiologists have corroborated the former empirical dictum that small areas can tolerate very large doses of unfiltered roentgen rays. Doses ranging from 1,000 to 8,000 r have been employed by Coste,[1] Grier,[2] and others, with excellent terminal cosmetic results.

The rather uniform and striking regressions obtainable stimulated our endeavor to help some of the patients with very far advanced and inoperable superficial carcinomata. Except for the occasional rodent ulcer case, these patients are usually very sick and frequently bedfast. They are far too often dramatic because most of them are victims of ignorance. We are all aware of the unfortunate patient who failed to seek medical advice until it was lamentably too late.

Intensive high voltage irradiation by either roentgen rays or radium, interstitially or in packs, has shown marked palliative effects from the standpoint of growth regression, but, in general, adequate heavily filtered radiation therapy is much too severe for this type of patient.

Since unfiltered roentgen rays have been demonstrated to be so effective for epitheliomata of the skin and lip, then equally good results should obtain for much larger lesions, providing the intensity of radiation is proportionate.

During the past five years, observations on the utilization of unfiltered roentgen rays have been extended to the treatment of inoperable, ulcerated, primary and recurrent tumors of the breast, vulva, rectum abdominal incisions and ulcerated glandular metastases, in addition to the advanced basal cell type of carcinoma. These lesions are all larger than 5 cm. in diameter, averaging about 10 cm.

Palliation and materially reducing the

* From the Radiological Department of the Philadelphia General Hospital, Philadelphia. Read at the Thirty-Fifth Annual Meeting, American Roentgen Ray Society, Pittsburgh, Pa., Sept. 25–28, 1934.

size of an unsightly process were the primary objectives. Bleeding from soft fungations and foul sloughs partially or completed subsided, concomitant with marked reductions in the size of the lesions. Regressions are usually phenomenally rapid, and the resulting wounds are relatively clean and compare favorably with an electrosurgical excision. The surface ulceration diminishes, probably due to healing with ensuing tissue contracture, the result of an extensive fibrosis. Lesions 5 to 6 cm. in diameter may show complete surface healing, a few of these cases being symptom-free four to five years.

### TUMOR GRADING

An attempt was made to record results and to modify the roentgen dosage according to the microscopic character and cellular differentiation of the neoplasm. There was no consistent radioresistance or sensitivity detectable, and there was ample evidence to justify ignoring these factors, because they would invariably suggest a plan of treatment that would unquestionably be inadequate.

Mixed basal and squamous cell type of carcinomata are not infrequent. Indeterminate cellular characters and differentiations are accentuated by complicating infection, fibrosis from previous inadequate treatment, and insufficient or necrotic biopsy tissue.

The fungations of a large so-called rodent ulcer required as much radiation as a recurrent breast cancer of similar size. On the other hand, a small unelevated or shallow basal cancer required about half the amount of treatment deemed necessary for a squamous cell type cancer. It must be emphasized that both the basal and squamous cell type of epithelioma are very often difficult or impossible to differentiate clinically, and even microscopically the differentiation may be exceedingly difficult. It is patent, therefore, that the safest procedure is to plan the maximum amount of radiation treatment that experience has dictated.

There is an abundance of clinical experience with the use of unfiltered roentgen rays in the treatment of skin cancer, and there are many reports of good results with dosage ranging between 1,500 and 8,000 r, for lesions 1 to 3 cm. in diameter and of varying thicknesses and depths.

This experience has been repeatedly demonstrated in our own clinic, without any complicating serious skin damage or late atrophy, but it is important that the intensity of radiation be regulated according to the size and thickness of the lesion.

The range for the minimum and the maximum dose is variously quoted from 250 to 2,500 r for fields less than 3 cm. in diameter. For relatively large fields, 10×15 cm., and 20×20 cm., the latitude extends between 250 and 1,200 r; i.e., unfiltered roentgen rays, 120 to 130 kv.

In a preliminary report[3] before this Society two years ago, evidence was submitted, on the basis of clinical observations, demonstrating a tremendous tissue tolerance for large doses of unfiltered roentgen rays. Case reports were submitted to illustrate results following doses ranging between 3,000 and 10,000 r, according to the size of the surface area and thickness of the lesion. The discussion was confined exclusively to the treatment of very large and inoperable new-growths. The types of cases for the most part were undertaken for palliative relief only. The procedure, from a practical standpoint, accomplished about as much as electrosurgical excision, but many of these cases were not suitable subjects for palliative surgery, for either the physical condition or the extent of involvement, or both, precluded any consideration of any surgical measures.

This presentation is intended to emphasize and corroborate the observations of the original report; to define more clearly its value and limitations; to offer a guide in the selection of cases, and to define our own experience as to the upper limits of dosage in terms of roentgens, according to the size, thickness and depth of the lesion.

The fundamental principle underlying

this work is the assumption of the almost universally accepted belief that all forms of radiation, regardless of wave length, have identical biological effects. This empirical premise must be adhered to in the light of information obtained with our present physical equipment and conclusions from much experimental evidence. At the Radiological Clinic of the Philadelphia General Hospital we are constantly confirming our clinical observations which seem conclusively to substantiate the experimental evidence of identical biological effects with different qualities of radiation.

This experience is briefly as follows: Epitheliomata of the lip, approximately equal in size (1 cm. in diameter), were treated with filtered and unfiltered roentgen rays (127 kv.); aluminum filters were 1, 2, 3, 4, 5, and 6 mm. Surface radium applications involved filtrations of 0.5 mm. of silver, 2 mm. of brass and 4 mm. of lead. Roentgen-ray intensities were based upon ionization measurements recorded in air. Radium doses were based upon the threshold erythema value as determined by innumerable skin tests. The clinical results were uniformly good with equal intensities of different qualities of radiation employed. This principle is adhered to in the routine work of our department because certain cases have been found to be more ideal for certain types of treatment. Every case is an individual problem and therapeutic procedures are adjusted according to the particular needs or circumstances.

Radiation qualities vary, therefore, only as to penetration and absorption. The soft or long wave length radiations from unfiltered roentgen rays (120 to 130 kv.) should theoretically be most ideal for the treatment of superficial cancer because of the greater absorption in the superficial layers of the tissue. The erroneous conception of a caustic action of the soft or long wave length quality of unfiltered roentgen rays is based upon effects resulting from greater intensities absorbed in the upper layers of tissue as compared with less absorption in the layers of tissue from the shorter wave length radiations. These well recognized physical facts are the foundation of all radiation procedures.

These are the principles that have stimulated research and have contributed to the progress of radiation in the treatment of deep-seated malignant disease by the development of shorter wave length radiations. In cancer therapy the aim has been to obtain greater depth penetration and absorption. By the same reasoning, a quality of radiation that will give effects of greater absorption, in the superficial tissues, should be ideal for large superficial lesions.

For practical purposes, it was considered that ulcerated neoplasms presenting a depth or thickness of 0.5, 1.0, 1.5 and 2.0 cm. and even more would be suitable for massive intensities of long wave length radiations. The sloughs, fungations and granulations act as tissue filtration. Large intensities can be administered because more than half the radiation is absorbed in the first 3 centimeters of tissue. This is all the more satisfactory because the normal tissue at the base of the disease is not subjected to the great intensities that would obtain if short wave length radiations were used. This obviates long treatment periods and the risk of commensurate radiation toxemias in patients with poor physical conditions.

Weatherwax and Robb[4] found that 1.5 cm. of water will absorb as much radiation as 0.5 mm. of aluminum (127 kv.); that 2 cm. of water will absorb as much as 1 mm. of aluminum, and that 3.2 cm. of water will absorb as much as 2 mm. of aluminum.

In actual clinical work, therefore, the first centimeter of tissue will absorb about 22 per cent of unfiltered roentgen rays (127 kv.), 2 cm. of tissue will absorb 44 per cent, 3 cm. of tissue will absorb about 60 per cent, and 4 cm. about 67 per cent.

The following factors are employed. Unfiltered roentgen rays: 127 kv. (crest value with 12 cm. spheres); 5 ma.; mechanical

rectification, effective wave length 0.42Å; erythema dose equals 500 r. (All ionization measurements are records of air intensities.)

The approximate thickness of the exuberant fungations or granulations and the square surfaces of the lesions were determined in millimeters or centimeters (estimated and photographed—not always actually measured).

The following cases are discussed in detail from the standpoint of technique because they represent the type of material, results and dose limitations according to surface area and thickness of the lesion. A rough standard of dosage for lesions larger than 5 cm. diameter has been formulated on the basis of an experience with 81 cases as follows:

Lesions elevated 1 cm. above skin surface; 5,000 r (10 S.E.D.)
Lesions elevated 2 cm. above skin surface; 7,500 r (15 S.E.D.)
Lesions elevated 3 cm. above skin surface; 10,000 r (20 S.E.D.)

The earlier experiences involved treatments given at the rate of 1,500 to 2,500 r two to three times a week. More recent experiences have been limited to treatments of 1,500 to 2,500 r once a week.

The slower rate of administering irradiation is favored because it affords an opportunity to temporize the treatment according to the clinical response. Occasionally, a predetermined plan of unfiltered roentgen irradiation must be changed to shorter wave length quality of radiation to adequately treat an unsuspected infiltrating process.

Case 1 (Fig. 1). Basal cell carcinoma of the scalp, 7×8 cm. and elevated 1.5 cm. above the skin surface, was treated with unfiltered roentgen rays (127 kv.). An intensity of 1,500 r was administered once a week for four treatments. (Total dose was 6,000 r.) There was complete regression of the growth within two months. A flat ulceration 2×3 cm., with thickening of the margins suggesting malignant disease, persisted for eight months. Radium was applied with a filtration of 4 mm. of lead. A dose of 3 S.E.D. was given. There was complete healing two months later. There has been no recurrence since treatment three years ago. The skin shows no evidence of atrophy or telangiectasis. The scar is small, thin, soft and pale.

This is a good clinical result. The treatment was conservative. The slow rate of administering the treatment is safe. To have given the total intensity of 6,000 r at one sitting would, in our experience, have involved the risk of slough and necrosis, and possibly a complicating bone necrosis which would have delayed healing considerably. Lesions larger than 5 cm. diameter and about 1 cm. elevation above the skin surface do not tolerate intensities greater than about 5,000 r unless the treatment is given in divided doses. This is the safest plan in our experience and it should be adhered to when there is a reasonable outlook of obtaining a clinical cure. It is likely that additional unfiltered roentgen rays would have caused delayed healing or necrosis of the persistent ulcer. The thickened edges were probably cicatricial, but there was also a strong suspicion of disease. We have noted on a number of occasions that short wave length radiations are bet-

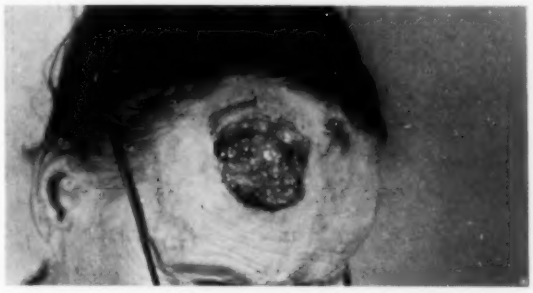

Fig. 1*a*. Case 1. August 11, 1931.

Fig. 1*b*. Case 1. November 11, 1932.

Fig. 2*a*. Case II. February 17, 1931.

Fig. 2*b*. Case II. January 8, 1932.

ter tolerated by tissues that have already received large doses of unfiltered roentgen rays.

Removal of lesions of this size and location with electrodesiccation or the radiotherm involve the risk of necrosis of bone, delayed healing and even recurrence. These complications have been encountered on several occasions.

Case II (Fig. 2). A squamous cell carcinoma involving the entire mucocutaneous surface of the lower lip was treated with combined unfiltered roentgen rays and heavily filtered radium. The thickness of the lesion in the center was about 1 cm. and approximately 0.5 cm. around the edges. An intensity of 1,500 r was administered once a week for two treatments. (Total dose was 3,000 r.) Approximately 7 S.E.D. of radium, with 4 mm. of lead filtration, was applied. Prophylactic high voltage irradiation to the neck was also given. There was complete regression of all clinical evidence of disease within six months. The skin shows no atrophy or telangiectasis. There is no recurrence since beginning treatment nearly three years ago.

An attempt to treat large cancers of the lip with unfiltered roentgen rays alone was not successful. Complete regressions have been obtained with intensities ranging between 7,500 r and 10,000 r, but the resulting ulceration was always complicated by induration about the margins. This induration was shown microscopically to be fibrosis and carcinoma. Further unfiltered radiation could not be considered because there was not sufficient tissue to act as filter. The superficial fungations had absorbed so much of the rays that the infiltrated bed of the disease was undertreated. If further unfiltered roentgen rays were employed then widespread breaking down generally occurred. On the basis of these experiences, unfiltered radiation is now always combined with heavily filtered radium treatments for squamous cell cancer,

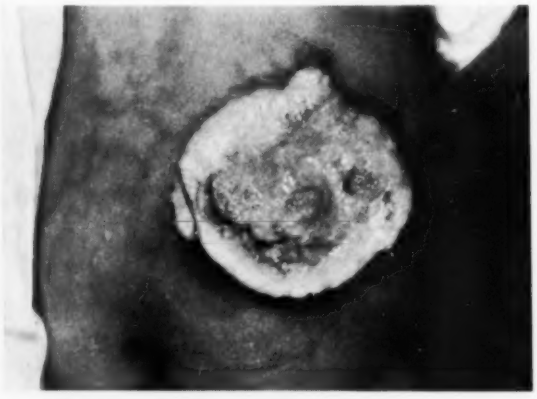

Fig. 3*a*. Case III. December 26, 1933.

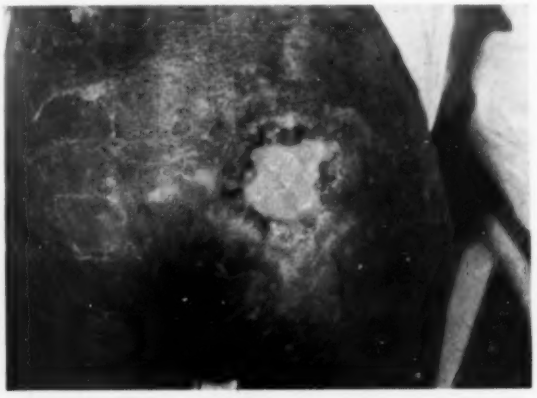

Fig. 3*b*. Case III. April 9, 1934.

Fig. 4*a*. Case IV. February 13, 1933.

Fig. 4*b*. Case IV. May 12, 1933.

particularly if there is a reasonable outlook of obtaining a clinical cure.

Case III (Fig. 3). An extensive fungating squamous cell carcinoma of the buttock was treated with unfiltered roentgen rays. The lesion was 12×14 cm. and 4 cm. elevation above the skin surface. During December, 1933, the surface of the lesion was divided into four quadrants; on seven successive days a total of 4,000 r, 5,000 r, 3,000 r, and 1,000 r was administered to each of four different areas. All parts of the cauliflower growth responded equally.

The center of the lesion received an intensity of about 10,000 r. Within four weeks the growth regressed to the surface of the surrounding skin. The contracture of the marginal tissues is evidence of fibrosis. There was no evidence of any marginal induration. The surface of the ulcer was clean and was equal to an electrosurgical dissection. The treatment was tolerated unusually well. Four months after treatment there was no evidence of any reaction on the skin to indicate radiation atrophy, or necrosis.

Death was due to extensive metastases. Autopsy revealed metastases to the inguinal nodes, tracheobronchial nodes, and to the left lung.

This case illustrates the remarkable effect of large doses of unfiltered roentgen rays from the standpoint of obtaining growth regression. This patient was very sick and the intensity of radiation that was given was well tolerated.

Case IV (Fig. 4). Extensive ulcerated inoperable carcinoma of the breast treated with three series of high voltage roentgen therapy without any appreciable evidence of reduction in the size or character of the fungating ulceration. The surface of the ulcerated area at the widest margins was 8×11 cm. and elevated 2 cm. above the surrounding skin surface. An intensity of 3,000 r of unfiltered roentgen rays was given on two occasions at the rate of one treatment a week. Total intensity of 6,000 r was given. Within six weeks there was practically complete regression of the fungating mass. Within three months there was marked contracture of the margins and base of the ulcer and nearly complete surface healing.

This case illustrates palliation from the standpoint of growth regression after failure of adequate high voltage roentgen irradiation. Fungations of this size have frequently been seen to regress with high voltage irradiation alone. If there had not been previous high voltage roentgen treatment the total intensity of irradiation

Fig. 5*a*. Case v. October 1, 1931.

Fig. 5*b*. Case v. February 19, 1932.

could have been considerably greater. Experience with this type of case has been larger than with any other anatomic site and the wide range of total doses has been found to be unusually great because of the underlying glandular structure which serves as an adequate protection against any possible excessive irradiation to bone and cartilage.

Case v (Fig. 5). Foul smelling fungating carcinoma of the breast which remained stationary in size and character after two series of high voltage roentgen treatment. The surface area was 9 cm. in diameter and elevated 1.5 cm. above the surrounding skin surface. An intensity of 5,000 r of unfiltered roentgen rays was given at the rate of 2,500 r once a week. Within a month from the beginning of the unfiltered roentgen treatment the surface granulations had regressed to the surface level of the surrounding skin. The granulations in the wound were clean. All odor had disappeared. The anxiety of the patient was greatly relieved and her mental state very much improved. The final outcome of the case was fatal because there were extensive glandular metastases.

These cases illustrate the value of unfiltered roentgen rays for palliative regressions that can be obtained in large fungations and ulcerations.

It is impossible to set forth any mathematical procedure of estimating the amount of treatment except in a very crude way.

More than 100 cases have been treated but 81 have been carefully studied from the standpoint of possible late skin changes over periods of three to six months.

## Conclusions

Unfiltered roentgen radiation has been demonstrated to be uniformly successful in effecting regressions of large superficial neoplasms.

Palliation is the objective. The results have generally only been palliative, except in an occasional case where clinical cures have been obtained.

Electrosurgery in many instances will accomplish as much. Usually these patients are not good surgical risks.

Unfiltered roentgen radiation can be administered very simply and conveniently. The procedure is conservative.

The good results obtained with fractional and massive doses of unfiltered roentgen radiation in the routine treatment of skin epitheliomata have prompted us to study its value for the very large lesions.

Tissue tolerance is much greater for small than for very large lesions.

The microscopic character and cellular differentiation at no time could be consistently used as criteria for resistance or sensitivity to irradiation.

The universal assumption that all qualities of radiation have similar biological effects and that more than half of the unfiltered roentgen rays is absorbed in the first 3 centimeters of tissue, and that the exuberant fungations may be utilized as filters or absorbing media, are the fundamental factors underlying the use of unfiltered roentgen irradiation for large superficial cancers.

The limitations of dosage are proportionate to the thickness of the lesion. A slow rate of irradiation on the basis of small doses once a week has been found to be desirable and effective. An average period of three to four weeks has afforded an opportunity to temporize a predetermined plan of treatment according to the response. This is a safeguard against excessive dosage, particularly with unusually sensitive lesions and inaccuracies in measuring the size of the growths.

Long and short wave length radiations should be combined for selected cases, particularly where experience justifies a reasonable outlook for a possible clinical cure.

REFERENCES

1. Coste, J. La roentgenthérapie des épithéliomas cutanés par un rayonnement moyennement pénétrant a feu nu, en une séance. *Arch. derm. syph.*, 1932, *4*, 195–222. Abs. in *Am. J. Cancer*, 1933, *19*, 892.
2. Grier, G. W. Radiation therapy of cancer of the skin. Am. J. Roentgenol. & Rad. Therapy, 1934, *32*, 206–210.
3. Widmann, B. P. Unfiltered roentgen rays for superficial cancers of wide and deep involvement. Am. J. Roentgenol. & Rad. Therapy, 1932, *28*, 526–540.
4. Weatherwax, J. L., and Robb, C. Personal communication. Investigations at Philadelphia General Hospital not as yet published.

DISCUSSION

Dr. John T. Murphy, Toledo, Ohio. For a good many years, we have been watching Dr. Widmann's work and we think that it offers a great deal for many of these cases. Our own technique has been carried on also for a good many years and has varied only in the method of giving the dosage. We have always treated these cases with upwards of 10 erythema doses. We have, however, in these larger lesions divided the field, as Dr. Widmann does and given, say, half or quarter of the lesion a dose and then move the field to the other side and give the same dose there. However, in many of these cases we have found that the complications which arise are not in those cases that involve the skin but those cases involving cartilage of the ear and the nose. In those cases, with the unfiltered radiation, our results have been disappointing many times. Now we do not use unfiltered radiations on these large lesions that involve cartilage. We use large doses of hard rays with heavy filtration. By that I mean that we use the divided dose technique and we give upwards of 4,500 r, 250 r per day. Especially, for instance, in an old case that involves the cartilage of the ear and the bone, we will say the mastoid, which is quite common in that type of case, we would give nothing but heavily filtered radiation.

Some of these cases Dr. Widmann showed cannot be classed, I believe, as hopeless cases. I think some of them will, as Dr. Widmann says, with a mixture of both the roentgen ray and radium be surprisingly well taken care of.

Now with carcinoma of the breast, I have never used his technique, preferring to use heavy doses of filtered radiation, and I think the advantage is this, that you get a prompt response in the tumor if you use enough dosage, a reduction in the tumor mass, while you have the skin healed.

We give enough roentgen radiation not only to reduce the size of the tumor but to loosen up the tumor from the chest wall, which you can do in many cases with heavily filtered

radiation, and then when the tumor is entirely loosened up (it usually takes six weeks after the radiation is given), the case is sent to the surgeon and the tumor mass removed. In this way we have been able to have some of these so-called incurable, inoperable breast cases remain well for five years in perfect comfort.

If we use unfiltered radiation on a lesion and decide, we will say, to give 6,000 r to a lesion, we give half of it, 3,000 r, one day and the second or third day following give the remainder of the dose.

I realize that Dr. Widmann's argument in favor of more division is a good one and I am wondering if right now we aren't at the stage where we are going to change our technique in all methods of irradiation and give more and more divided doses. By divided doses I don't mean the type of divided doses that the ordinary dermatologist gives to malignancies of the skin where he gives 75 r from now on. I mean the type of divided dose, for instance, that has been advocated by Coutard in carcinoma of the larynx, taking perhaps twenty-one or thirty days to give the dose, giving a suitable amount each day.

Dr. Widmann (closing). Dr. Murphy has brought up an important point. Large doses of unfiltered roentgen rays to extensive lesions complicated by a mixed infection and involving cartilage and bone have not been found to be beneficial for recurrent lesions and more particularly for lesions that have been refractory to routine irradiation procedures. These cases should receive the benefit of intensive short wave length irradiation.

The use of large doses of unfiltered roentgen rays involves the necessity of careful protection of the surrounding normal skin. A large lip lesion is manipulated so that the tongue is protected by gauze packing and the surrounding normal structures are shielded with lead foil.

Vol. 34, No. 5

# PRELIMINARY REPORT ON 300 KV. TREATMENT MACHINE*

*By* JOHN T. MURPHY, M.D.
TOLEDO, OHIO

TODAY with roentgen therapy in a transitional stage, the eyes of the medical world are focused upon us with the hope that by new methods and new machines we may increase our efficiency in the fight against cancer. Let us not make it more difficult for ourselves by being over-enthusiastic. We should be chary of promises that we find later cannot be fulfilled. We all remember the glowing claims made for 200 kilovolts and the massive dose technique. We all now know that many of these early hopes were not realized.

For years we have known that many cancers are cured with roentgen rays, when the proper amount is applied to the growth. Since 1916 I have used doses of from 4,500 to 6,000 r of unfiltered roentgen rays on carcinoma of the lip and in uncomplicated cases the use of this dose has made lip cancer a curable disease. Those of us who have been doing therapy since the early days have seen cancer patients improved by the use of the lower voltages. They improved to a certain point only to relapse and die. We have also felt that as voltage and filtration increased we had more regressions and we know some of these cases have remained free from symptoms of disease for long periods. Some of these improved results were due to improved technique, but we did not feel that this was the only cause. We felt that increased voltage, with greater energy in the depths, a shorter wave length with perhaps a different biological effect, was responsible for some of this improvement.

It is reasonable, therefore, to assume that if cancer of the lip responds to heavy surface dosage, and if by increased voltage deep-seated cancers improve, with still higher voltages we might bring about a regression in a large percentage of the cases. We now have apparatus that will produce almost any desired voltage. We have exact measurement of output of these machines. The wave length and absorption rate have been calculated, and surely now we are equipped to see what can be done. Our problem then is, can a similar amount of energy that has proved successful in carcinoma of the lip be delivered to deep-seated tumors and not destroy the patient? If this can be done, what voltage is required and what technique is best? It is important to determine not the maximum voltage, but the minimum voltage that will do this. It will be a waste of human life not to use this minimum, for only at a minimum expense can we make roentgen irradiation available to all. It is my belief that the cancer problem must be handled at a minimum expense and in many places and not at a maximum expense in widely separated places. This country is far too large for the latter arrangement.

To help solve this problem we have chosen a medium voltage machine, moderate in price, moderate in upkeep. It uses a standard sealed tube, has little variation in output once standardized, and its proper use rests more upon a knowledge of the disease than upon a knowledge of mechanics or physics.

## THE MACHINE

The transformers are of 400 kv. capacity at 15 ma. of current. Because no sealed American made tube of over 300 kv. capacity is available, it is being run at 300 kv. and at 10 ma., the tube capacity. The measurements of the output of the machine were made by Dr. Otto Glasser and are as shown in Table 1.

The machine and treatment couch, except the control, are installed in a room

* Read at the Thirty-fifth Annual Meeting, American Roentgen Ray Society, Pittsburgh, Pa., Sept. 25–28, 1934.

TABLE I

OUTPUT OF 300 KV. MACHINE

| Filter | Radiation in r per minute | | | Effective wave length in Å | Depth dose for 10 cm. large area | | |
|---|---|---|---|---|---|---|---|
| | 55 cm. F.S.D. | 70 cm. F.S.D. | 80 cm. F.S.D. | | 55 cm. F.S.D. | 70 cm. F.S.D. | 80 cm. F.S.D. |
| 2.08 mm. Cu + 1 mm. Al | 38.1 | 23.6 | 18.0 | 0.100 | | | |
| 3.12 mm. Cu + 1 mm. Al | 27.8 | 17.2 | 13.1 | 0.081 | 46% | 48% | 49% |
| 5.20 mm. Cu + 1 mm. Al | 18.0 | 11.1 | 8.5 | 0.075 | | | |
| Thoraeus Filter I | 49.2 | 30.4 | 23.2 | 0.094 | 44% | 46% | 47% |
| Thoraeus Filter II | 39.2 | 24.2 | 18.5 | 0.086 | 46% | 48% | 49% |

17 feet 10 inches by 10 feet 4 inches with a ceiling height of 7 feet 10 inches. The clearances are figured for 400 kv., so that to change to this voltage it is only necessary

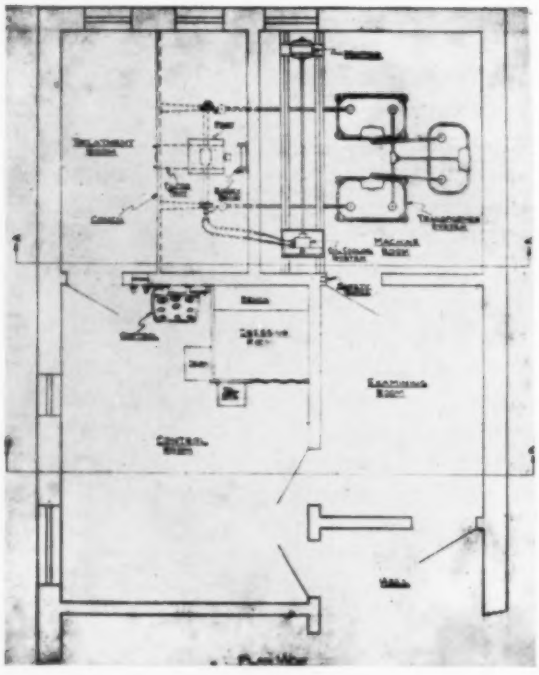

FIG. 1. General layout of treatment unit.

to install a new tube at the proper distance from the patient. The equipment is installed in the basement, so that the outside walls need no protection. The lead protection used is 1/2 inch on the top of the couch, on the end of the box toward the operator and the same amount on an area 4 feet square on the ceiling directly above the patient. The remainder of the ceiling of the treatment room has 3/8 of an inch, as have the side of the box and the entire wall closest to the operator. The ceiling of the transformer room has 1/8 inch lead. There is very little stray radiation in the operator's room. The open box installation of the tube has been in use since 1921 and has proved very satisfactory for both air and water cooled tubes. The use of the couch has been criticized, but with reasonable care and practice, it is rarely a handicap. Whatever defects it may have I feel are more than made up by the favorable reaction of the nervous patient, because he sees no machinery in the treatment room. The lead on the walls and couch also deadens the noise of the water cooling machinery and blower fan, so there is little noise. The largest portal is 25 by 25 cm. and the weight of the patient is kept from the filter by the use of an ordinary Bucky compression strap fixed across the opening in such a way that the tension can be kept uniform. The size of each area treated is determined by lead cut outs 3/8 inch in thickness, laid on top of the compression band directly in contact with the patient. These can be quickly and easily changed to suit the individual case. The filters are in a tray which can be taken out without disturbing the mattress, the tension strap or the patient. A safety switch does not allow the machine to be started unless the filter tray is in place. As an added security the tray is wired for six circuits, with cor-

responding lugs fixed on the filters. These lugs complete circuits that light lamps, one for each filter, on a panel in front of the operator. At any time during the treatment it is only necessary to glance at this panel to tell which filter is in use. The filter signal has been a great satisfaction to us in our work. The method of installation is electrically safe with no high tension cable or insulators to burn out. It is moderate in price, easy to install, and the operating charges have been satisfactory. The present tube has run about 300 hours.

### SKIN ERYTHEMA DOSE

In the problem of delivering adequate doses to tumors in the depths, it is necessary to consider the surrounding tissue and one of the greatest barriers has been the skin. Much discussion has arisen over this point. Back-scattering and its effects have been discussed by those competent to do this. I shall confine myself to clinical results. Increase in skin tolerance with increased voltage and filtration is basic, because upon it higher voltages rest some of their claims. The question of threshold erythema for any voltage is not absolutely settled. This is evidenced by the fact that various observers, using 200 kv., 0.5 mm. copper, differ as to the number of roentgens required. Some place it as low as 450 r,

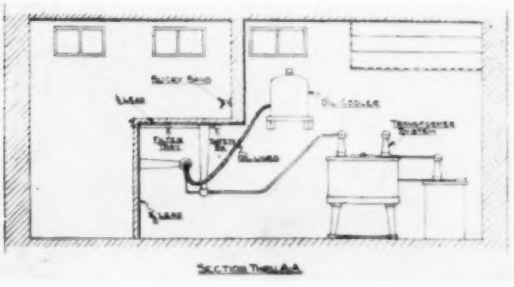

Fig. 2. Cross section of installation.

some at 600 r, using medium-sized fields. Here is a considerable variation which adds to the difficulty in evaluating any difference in the number of roentgens required to produce an erythema at 300 kv. To add to my difficulties I have never used a full dose over a field at one time, always giving not more than 1/3 of the estimated skin dose over a field in a twenty-four hour period. Therefore, I will present my observations.

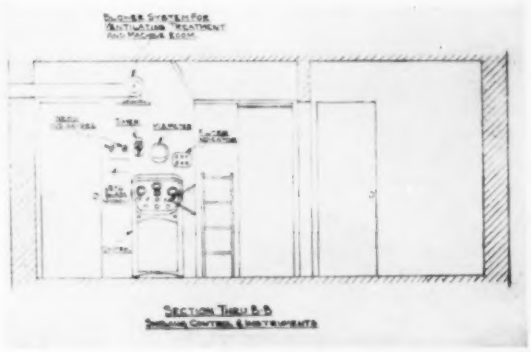

Fig. 3. Detail of control stand.

Using a field 15 by 15 cm., giving 343 r (300 kv., Thoraeus filter, 0.4 mm. tin, 0.25 mm. copper, 1 mm. aluminum, time 7 minutes) per day for three days or forty-eight hours between the first and third treatments, a total of 1,039 r produced a mild erythema. This treatment was applied to the posterior part of the thoracic wall. This has left a definite and persistent tanning. Nine hundred roentgens given in the same manner produces the same results when given with 200 kv., 1 mm. copper.

With a four field technique for pelvic treatments, one anterior, one posterior, and two lateral, using the same factors, treatment given each day except Sundays, 16 treatments in all, 1,372 r over each field caused a brisk reaction with superficial ulceration and desquamation. This erythema of course varied with different thicknesses of patients. The variation was especially noticeable in the lateral fields.

Twenty-four hundred roentgens given in eight days to a 10 by 15 cm. field on the axilla and chest wall produced a sharp erythema of the entire field. Of course it was more marked in the axilla, where complete desquamation and ulceration occurred. This reaches its maximum about two weeks after the last treatment and heals in about four weeks, leaving a deep tanning.

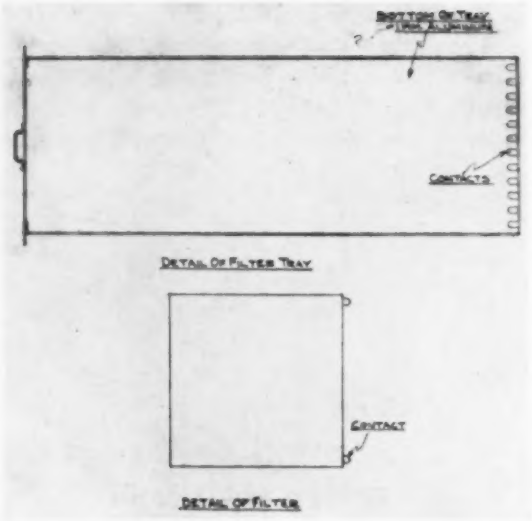


Fig. 4. Detail of filter tray and filter.

In the larger doses given in carcinoma about the neck, the advent of the mucositis and epithelitis closely parallels the published reports of Coutard and it is difficult to note any differences in the amount of skin changes. With the divided dose technique we have used as high as 5,635 r in twenty-six days over a 10 by 10 cm. field in a case of carcinoma of the larynx with perfect healing. This amount has left the skin soft and pliable.

In one case of advanced carcinoma of the lung, using a 15 by 15 cm. field, 3,087 r was given in thirteen days on a posterior field. The next day a lateral field of the same size was started and 3,440 r given in fourteen days. Two days later a third field anteriorly was started and 4,116 r was given in sixteen days, or a total of 10,643 r over three fields in forty-three days. There was, of course, a marked skin reaction with ulceration which required about ten weeks to completely heal.

Now as to effects in the depths. In the cases where 2,400 r was given over the axilla and chest with the rays directed upward through the supraclavicular region, so as little as possible would pass through the lung, most patients complained of feeling soreness when swallowing. This they attributed to a slight cold.

Patients of average size, with pelvic lesions, usually about the time the anterior and posterior fields are completed (two fields, 1,372 r to a field, eight treatments in about ten days) develop a definite bowel irritation with diarrhea. This must be controlled with paregoric to finish the series. These bowel symptoms are a serious disadvantage. I do not know how much injury the mucosa of the bowel will stand and regenerate. I am aware of reported cases of late ulceration of the bowel, but I believe most of these to be due to repeated series of treatments. The vaginal vault at this time shows a marked congestion and an inflammation, which unless care is taken will close the vagina and make subsequent examinations and vaginal treatment difficult. We attempt to avoid this vaginal closure by the use of saline douches twice a day and vaginal examinations to free what adhesions are formed.

In the mouth and neck the effects appear not to differ from previous experience with lower voltages. There is little difference either in the time of the appearance or the reaction. The patients are very uncomfortable, but while the number so treated has been small, in no case has surgical intervention been necessary and few have needed to be hospitalized. They all have difficulty in eating and must take only liquid food for as long as two or three weeks.

It is interesting to note, in view of published accounts of changes in the heart due to irradiation, that in the case of car-

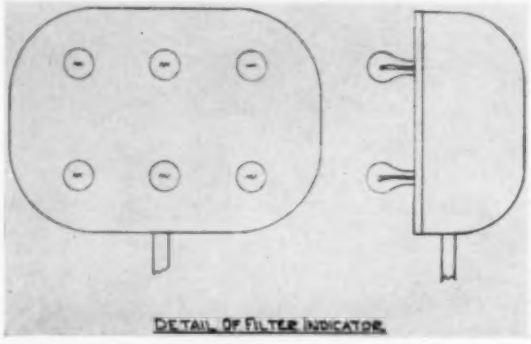


Fig. 5. Detail of filter indicator.

cinoma of the lung, where a total of 10,643 r in forty-three days was given to a lower right lobe tumor, much of this radiation must have passed through the heart. Neither by clinical examination nor by the electrocardiograph was it possible to demonstrate changes in this organ. Possible late changes in deep organs must be kept in mind in all cases where large doses are used. In cases where the neck has been irradiated changes in the deeper tissues have remained, as evidenced by a hoarseness and some puffiness of subcutaneous tissue. As yet I have seen no permanent bad effects on the bowel. The inflammatory reaction seems to subside and leave no residue with the dosage we have used. Most cases were given an additional series about two months after the first. Only three-quarters of the original dose was used and no bowel symptoms occurred. Because I am convinced that lung fibrosis follows heavy doses, I have hesitated to use more than 1,700 r over a field when irradiating local breast recurrences with no demonstrable lung involvement. With this dose we do get reactions in the pleura with pain on breathing. This amount is purely arbitrary and may be too high or too low. Time will tell.

The following case is open to question, but is suggestive:

This patient was irradiated elsewhere following a radical breast operation; 3,860 r over each of two large fields, one anterior and one posterior, divided dose technique and a very heavy voltage, was given. These treatments were given in February, 1934. Following this she was fairly well until May 1. She had lost weight, was short of breath and had a dry brassy cough with elevation of temperature. The question of recurrence was discussed, but a beginning fibrosis of the lungs was diagnosed. The next roentgenogram made on May 15, 1934, showed a definite regression in the lower part of the lung with increased density higher up. The last roentgenogram made August 21, 1934, showed the heavy shadow nearly gone, but a definite increase in markings over the entire area. At the present time the patient appears clinically well. The regression of the original lesion with its recurrence later in a different area rules out metastatic carcinoma. The residual thickening, I think, indicates that the process will continue producing such results as reported by Dr. Leucutia of Detroit. Unfortunately no preoperative plate was made in this case, but the patient had no clinical disease other than the cancer when operated upon.

### ROENTGEN SICKNESS

Roentgen sickness is reported by some authors to have vanished with the use of higher voltages. This is not true with 300 kv. The general effects are the same as with lower voltages. It is my opinion that many factors have a bearing on roentgen sickness. The most important are: size of the dose, size of the field, location of the area treated, general condition of the patient, and the psychic element. The most important of these is the number of roentgens used and the size of the field. It has been our experience that a daily dose of 250 r, 15 by 15 cm. field, rarely produces more than a slight malaise, while 350 r per day with the same field will produce nausea and even vomiting in some patients. Larger doses will produce definite nausea and vomiting. All radiation therapists know that roentgen sickness follows treatment over some areas of the body more than others. Even small doses over the upper abdomen and the chest will often produce symptoms, while heavy doses over areas about the neck will not do so. The general condition of the patient is very important. Anemic, poorly nourished, exhausted patients will have roentgen sickness much more frequently and with smaller doses than will those who are in better physical condition. The fact that the psychic element enters into many cases of roentgen sickness is well known. Elimination of noise and fear producing machinery is a definite aid in this type of individual. Poorly ventilated treatment rooms add to the incidence of this complication in all types of patients. It is my opinion that the important factor is the amount of energy applied to the patient.

While we are discussing the effects of the

larger doses of roentgen radiation, it might not be amiss to stress a very important thing, the education of the profession and the public to the fact that reactions of the skin and deeper structures are a necessary accompaniment to the proper and accepted use of roentgen therapy and that these changes must be accepted as a part of the treatment of cancer. There are many radiation therapists avoiding these changes because of fear that they may be misinterpreted by the patient. A frank discussion of the case with the patient, if possible, if not, with a responsible close relative, telling just what to expect and when to expect it, will in most cases make for a cooperation that will result in far better work.

## CONCLUSION

In conclusion, it seems to me that with 300 kv. we have moved a step forward. This may be due to increased doses, different biological effects, or both. A longer time to test the results will answer these questions.*

* For discussion see page 673.

Vol. 34, No. 5

# ROENTGEN THERAPY WITH 700 KV.*

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IN 1931 a building was erected at Memorial Hospital to house a high voltage roentgen-ray apparatus loaned by the General Electric Company. The cascade tube, designed by Coolidge, Dempster and Tanis, for operation at 900 kv. along with the high voltage generator, was installed during that summer and the first patient was treated with it in October, 1931.

Most of the exposures, either for physical, experimental or treatment work, have been at 700 kv. and 5 ma.

In a symposium at the meeting of the American Roentgen Ray Society in 1932 some of the observations on the physical, biological and clinical experiments were presented under the title, "The relative effects produced by 200 kv. roentgen rays, 700 kv. roentgen rays and gamma rays."[1]

The distribution of radiation in a water phantom was investigated by Failla, Quimby, Marinelli and Rose, under comparable conditions for 200 kv. roentgen rays, 700 kv. roentgen rays and gamma rays. The *relative* doses at 10 cm. depth were respectively 29.0, 41.2 and 56.7 per cent. Accordingly, from this point of view, 700 kv. roentgen rays are considerably better than 200 kv. roentgen rays, but not as good as gamma rays. However, since the high cost of large quantities of radium prevents its use at distances comparable to those generally employed in roentgen therapy, the advantages of the greater penetration of gamma rays are not fully utilized in practice. (The depth dose at 10 cm. when a radium pack is applied, 15 cm. from the skin, is approximately the same as that for 200 kv. roentgen rays at 50 cm.) The 700 kv. apparatus thus provides a greater depth dose than either 200 kv. roentgen rays or gamma rays, under the usual conditions during which treatments are given.

Biological, physical and clinical studies of the quality of the 700 kv. roentgen rays were made by Henshaw, Henshaw and Francis; by Bagg and Halter; by Duffy, McNattin, Copeland and Quimby. These were correlated and discussed by Failla, who concluded that "quality of radiation *per se* very probably plays an important part in radiation therapy. . . . The experiments with 700 kv. roentgen rays show that the behavior of this quality of radiation is intermediate between that of 200 kv. roentgen rays and gamma rays. Hence better clinical results may be expected from the use of very high voltage roentgen rays on two grounds: (1) Because of greater depth doses obtainable, and (2) because of the very probable greater differential action on the tissues of the human body, whether direct or indirect."

Henshaw and Francis investigated the biological effectiveness of 165 kv. roentgen rays, 700 kv. roentgen rays and gamma rays in wheat seedlings and *Drosophila* eggs. While a differential effect was noted, it was considered to be too small to be significant.

The use of roentgen rays today in the treatment of diseases is based largely on the results obtained through the application of certain known quantities of radiation rather than on a specific or differential effect of the quality or wave length of the rays. There have been, no doubt, many clinical observations and some laboratory experiments to indicate that the quality of radiation may exert a specific or differential effect, apart from the amount of radiation absorbed. There has been no absolute clinical proof of this owing to the difficulty of the problem entailed by the

[1] Am. J. Roentgenol. & Rad. Therapy, 1933, *29*, 293–367.

* Read at the Thirty-fifth Annual Meeting, American Roentgen Ray Society, Pittsburgh, Pa., Sept. 25–28, 1934.

physical factors as well as the biological factors involved. Until more is known about normal cell growth and the chemical processes involved, radiation treatment of new growths must necessarily be based on physical considerations. In other words, when prescribing roentgen therapy, the roentgenologist has in mind the effect of quantity of radiation rather than the quality or wave length of the rays absorbed. This, then, has the effect of placing the radiation therapy of cancer in a surgical conception or theory of its control or cure, or eradication through indirect or direct destructive or caustic action, depending on the amount and rate of the radiation absorbed in the area exposed.

Therefore, the efforts of radiologists, physicists, and other workers in this field have been directed toward the production of larger quantities of more highly penetrating rays and factors making for an increase in depth dose or amount of radiation delivered to the area of disease, with less or a minimum of damage to normal or uninvolved structures. These and the following statements, although elementary, as all roentgenologists know, indicate the trend of theory and practice since the beginning of the application of radiation in the treatment of neoplasms.

Increase of filtration changes the *composition* of the roentgen beam by eliminating a certain proportion of less penetrating longer waves. Since the interposition of greater filtration does not *add* any shorter wave length radiation to the beam, but actually *subtracts* from it that fraction of long wave length roentgen rays unable to pass the filter, an effect of this change is a great reduction in the total energy which actually reaches the skin, even though the beam is composed of an increased proportion of penetrating rays. This reduction in quantity to reach the skin necessitates extravagant prolongation of the time of treatment, an alteration of the time factor which may possibly account for any improvement in results.

In similar fashion, an increase of the target-skin distance is accompanied by an increase in the percentage depth dose. The inverse square law must necessarily be considered, its operation requiring lengthy exposures and the time element here should be taken into account in any comparative estimate of results.

An interesting observation is the alteration in the quality or wave length of rays traversing soft tissues, and undoubtedly the composition of the rays absorbed in tumors at various depths should be taken into account when considering not only the amount of dosage but the relative effectiveness of 200 kv. roentgen rays, 700 kv. roentgen rays and gamma rays of radium.

It is now well known that the primary beam in traversing soft tissues, or matter such as paraffin, is split up and the scattered radiation resulting is softer, of longer wave length and varies in these characteristics with the depth beneath the surface.

Another factor of considerable importance in the clinical treatment of growths is the time factor or degree of intensity and the different changes produced thereby in the tissues. The microscopic picture, as well as the gross clinical evidence of slow degeneration, accompanied by efforts at repair, resulting from light doses of low intensity or small amounts of radiation, delivered daily over a long period of time, is in contrast to the rapid changes produced by large doses of high intensity of radiation within a comparatively short time. Obviously the selection of the method of treatment entails a consideration of numerous factors, which include radiosensitivity, bulk of the tumor, extent of the disease, age of the patient, his general condition, etc.

Elderly or enfeebled patients in poor general condition, of course, do not well tolerate protracted irradiation and care should be taken in the selection of patients for a long course of daily roentgen treatments.

## SUMMARY OF CASES TREATED

The majority of our patients were given treatments daily, 300 to 400 r, two or more

portals, some every other day and a very few were given only a few heavy doses all within a week or so.

In all, 150 patients were treated from October, 1931, to January, 1934.

### DISTRIBUTION OF THE LESIONS TREATED

| | |
|---|---|
| Breast | 19 |
| Axilla | 1 |
| Lung and bronchus | 16 |
| Skin | 5 |
| Bladder | 7 |
| Prostate | 2 |
| Teratoma testis | 12 |
| Rectum | 4 |
| Cervix | 11 |
| Corpus uteri | 1 |
| Ovary | 2 |
| Stomach | 7 |
| Esophagus | 4 |
| Pancreas | 1 |
| Sarcoma of the mandible | 1 |
| Sarcoma of the ilium | 1 |
| Extremities (bone) | 5 |
| Extremities (soft part) | 5 |
| Pharynx and nasopharynx | 8 |
| Tongue | 7 |
| Tonsil | 15 |
| Extrinsic larynx | 10 |
| Other intraoral | 5 |
| Inguinal nodes | 1 |
| TOTAL | 150 |

### ANALYSIS OF PATIENTS ACCORDING TO METHOD OF TREATMENT

Analysis of the 150 patients who received treatment reveals the following:

| | | |
|---|---|---|
| Cases treated only by 700 kv. | | 67 |
| Cases suitable for analysis, although gold seeds were employed in the residual primary tumor after the effect of the 700 kv. treatment had been noted | | 8 |
| Cases suitable for analysis, although gold seeds were employed in the residual metastatic tumor after the effect of the 700 kv. treatment had been noted | | 12 |
| Cases suitable for analysis, although gold seeds were employed in the residual primary and metastatic tumors after the effect of the 700 kv. treatment had been noted | | 2 |
| Cases unsuitable for analysis because treatment included some 200 kv. roentgen therapy | | 53 |
| Cases which received 200 kv. therapy previous to treatment by 700 kv. unit | 23 | |
| Cases which because of breakdown of the 700 kv. unit had to be treated by 200 kv. later | 30 | |
| Cases unsuitable for analysis because treatment included tandems and special radium applicators | | 6 |
| Cases unsuitable for analysis because treatment included radium element pack | | 2 |
| TOTAL | | 150 |

### UNCOMPLETED TREATMENTS

Four patients did not complete their treatments for the following reasons:

1. Carcinoma of the stomach. Death from sudden hemorrhage.
2. Extrinsic carcinoma of the larynx. Death from weakness and cachexia.
3. Carcinoma of the lung; rapid decline; treatment discontinued.
4. Carcinoma of the breast; patient obtained employment and did not return.

*Comment.* It should be noted that the above tables reveal that only 89 of the 150 cases treated were suitable for analysis. Thus, 61, or 42 per cent of the cases, because of the admixture of other modalities of radiation, are of questionable value in determining the efficacy of this 700 kv. roentgen unit. Slightly more than 50 per cent of these unsatisfactory cases were the direct result of mechanical breakdowns in this unit resulting in suspension of service.

### CLASSIFICATION OF PATIENTS ACCORDING TO EXTENT OF DISEASE

Study of the extent of disease of the 67 cases treated by the 700 kv. unit *alone* reveals that only 12 were favorable cases, while 55 were patients with advanced disease (82 per cent). The extent of disease and whether now living or dead are shown in the table at the top of the next page.

### CLASSIFICATION OF PATIENTS ACCORDING TO GENERAL CONDITION

| | |
|---|---|
| Advanced disease, good general condition | 21 |
| Advanced disease, fair general condition | 19 |
| Advanced disease, poor general condition | 15 |
| Total number of advanced cases | 55 |

### FAVORABLE CASES

| | |
|---|---|
| Early and borderline cases, good general condition | 6 |
| Early and borderline cases, fair general condition | 5 |
| Early and borderline cases, poor general condition | 1 |
| Total number of favorable cases | 12 |

| Extent | Number | Dead | Living | Living with disease | Living without disease |
|---|---|---|---|---|---|
| Favorable | 12 | 4 | 8 | 5 | 3 |
| Advanced disease | 55 | 32 | 23 | 12 | 11 |
| Total | 67 | 36 | 31 | 17 | 14 |

*Comment.* The preponderance (82 per cent) of cases of advanced disease in the patients treated by this unit should be noted. Actually, among the 67 cases suitable for analysis only 2 could be classified as being in an early stage, and neither of these was a radiosensitive tumor.

### RESULTS OBTAINED

Favorable Cases—Of the 12 cases classified as favorable, 4 are dead, 8 are living, 5 of whom still present evidences of disease. Three patients of the original 12 are living and are clinically free of disease (25 per cent).

Advanced Cases—There were 55 patients with advanced disease. Thirty-two of these are dead; 23 are living. Of these 23 living patients, 12 still have disease present. Eleven are clinically free of disease (20 per cent).

### REGRESSION

| Extent of Disease | Degree of Regression | | | | |
|---|---|---|---|---|---|
| | Number | Complete | Moderate | Slight | None |
| Favorable | 12 | 5 | 4 | 0 | 3 |
| Advanced | 55 | 19 | 10 | 11 | 15 |
| Total | 67 | 24 | 14 | 11 | 18 |

The figures submitted in this report should be regarded only as tabulations. Statistics showing end-results in the surgical or radiological treatment of cancer cases often reflect or indicate, to a considerable degree, the knowledge based on experience in this field, technical skill and clinical judgment of the surgeon or radiologist rather than, or as much as, they do the value of the method of treatment or agent employed. And this article is intended to be a report only of observations to date on the clinical use of roentgen rays generated with 700 kv.

Such machines provide for greater depth doses and high intensities. Thus, in the treatment of certain deep-seated or radioresistant tumors, they can produce better clinical results with less damage to skin and normal structures. Although these machines will not necessarily replace the 200 kv. machines now in general use, it is our belief at this time that they will increase the range of usefulness of roentgen therapy, especially in the larger institutions where a large number of patients and a great variety of tumors are treated.*

* For discussion see page 673.

PATIENTS FREE OF DISEASE

*Favorable Cases*

A. J.
Ca. nasopharynx with cervical metastases. No evidence of disease 14 months.

D. C.
Ca. breast with axillary nodes; 7 months' pregnant. No evidence of disease in breast; 15 months.

W. W.
Ca. alveolar ridge and cheek. No evidence of disease 17 months later.

*Unfavorable Cases*

K. E.
Ca. base of tongue with cervical metastases. No evidence of disease one year.

F. R.
Lympho-epithelioma nasopharynx with cervical metastases. No evidence of disease 15 months.

G. C.
Ca. breast, 7 cm. diameter. No evidence of disease 21 months.

L. H.
Transitional cell ca. pharynx with cervical metastases. No evidence of disease when lost track of 9 months later.

A. B.
Advanced ca. bladder. No evidence of disease 22 months.

P. P.
Advanced ca. breast. No evidence of disease 2 years.

*Unfavorable Cases*

M. R.
Lympho-epithelioma left tonsil, with cervical metastases. No evidence of disease 13 months. Since then recurrence has developed.

C. S.
Ca. tonsil with cervical metastases. No evidence of disease 31 months.

I. F.
Ca. tonsil with cervical metastases. No evidence of disease 23 months.

E. S.
Ca. tongue; bilateral cervical metastases. No evidence of disease 20 months. Developed new primary in lower esophagus. Double cancer.

# THE PROBLEM OF UNIFORM DISTRIBUTION OF THE RADIATION FIELD IN SUPERHIGH VOLTAGE ROENTGEN THERAPY WITH TUBES OPERATING ON A CONTINUOUS PUMP*

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PERHAPS the most important requisite of successful irradiation, especially when using large portals of entry, is the uniform distribution of the radiation field which is defined as the uniform intensity of the cross section of the irradiating roentgen beam. Since this uniformity is the result of certain factors of the cathode-ray focal spot and of the target, assuming that the off focus radiation has been eliminated as much as possible, the problem resolves itself primarily into one of tube construction. In the sealed roentgen tubes, because of the close proximity of the cathode and target and because of other resourceful designing ideas which are incorporated (helical focus, line focus, Lilienfeld effect, etc.), the question may be considered as having reached satisfactory solution both from the engineering and the medical standpoint. Indeed, the construction of the cathode and target elements in most tubes is simplified to such an extent and duplicated in the various tubes of the same make with such a fine degree of precision that the roentgen therapist can safely assume that the beam of the average roentgen tube put at his disposal is of sufficient practical uniformity, and a cursory checkup measurement is all that is required of him. Also, during the course of prolonged operation, he will experience little trouble in this respect, the tube maintaining the uniformity of field intensity for a long while. It is a different matter, however, with the roentgen tubes operating with a continuous pump at superhigh voltages. Here, because of the increased distance which by necessity of construction must be between the filament and target and because of a series of hazards inherent in the great electrical stress present, a distortion of the radiation field may occur for various reasons at any time during the operation or whenever parts of the cathode or target elements are replaced.

## TYPES OF FILAMENT-TARGET ARRANGEMENT IN SUPERHIGH VOLTAGE ROENTGEN TUBES OPERATING WITH A PUMP

From the point of view of the filament-target relation, we may divide the present superhigh voltage tubes operating with a pump into two groups:

(*a*) The multisectional anode grounded roentgen tube of Coolidge[1] which has the essential feature that the filament containing cathode is at one end of the tube and the target at the other grounded anode end (Fig. 1). In this way, the filament-target distance is a long one, in some tubes as long as 14 feet. Since the cathode rays must traverse the entire length of the tube before impinging upon the target, an appreciable divergence of their beam will result. The electrostatic field between the electrodes of the subsequent sections of the tube will have a tendency to reduce the divergence, but, even so, the focal spot will remain exceedingly broad (at least 10 cm. in diameter). To obviate this, Coolidge provided around the anode end of the tube a magnetic focusing device which narrows the cathode-ray beam to any desired size before impinging upon the target. Thus the focal spot at the target is controlled by increasing or decreasing the current of the focusing coil. To illustrate the operation of this device, we may take one single ex-

* Read at the Thirty-fifth Annual Meeting, American Roentgen Ray Society, Pittsburgh, Pa., Sept. 25–28, 1934.

ample:[1] to produce a focal spot of 1 cm. in diameter at 460 kv. (coil), a current of about 1 ampere is necessary in a 4,000 turn focusing coil, and to broaden it to 6.5 cm. in diameter, an elevation of the current to 1.3 amperes is required. An increase in the high voltage of the tube entails some increase in the current of the focusing coil to give the same focal spot so that if, in our case, the voltage of the tube is increased from 460 kv. (coil) to 700 kv. (coil) the current must be raised to 1.1 amperes to obtain a focal spot 1 cm. in diameter.

(*b*) The unisectional anode grounded or mid-grounded roentgen tubes[3] which all have the characteristic that the filament containing cathode and the target are brought rather close together (Fig. 2). In the anode grounded tubes, the filament is mounted in a cup at the free end of a cathode rod which projects through the entire length of the tube within a very short distance from the target, while in the mid-grounded roentgen tubes the arrangement is very much like that in an ordinary roentgen tube with a metal discharge chamber, except for the larger dimensions inherent on the higher voltages. It may be

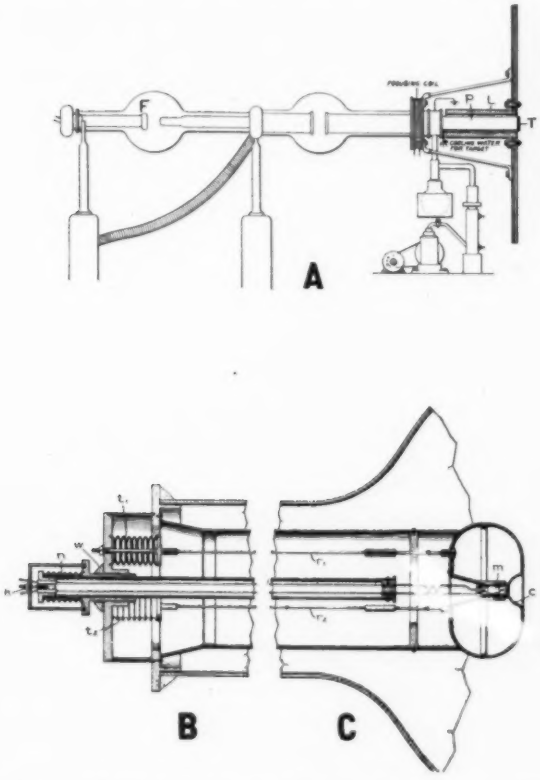


Fig. 1. Multisectional anode grounded glass roentgen tube. *A* shows ensemble of tube, filament target relation and magnetic focusing device of the cathode beam before striking the target. *F*, filament; *T*, target; *P*, brass cylinder, at the end of which is mounted the target; *L*, protective sheet lead envelope. *B*. Details of cathode adjuster. $r_1$, $r_2$ (and $r_3$ not shown in diagram), metal rods which can be moved with the aid of $t_1$, $t_2$ (and $t_3$) sylphon tubes, without breaking the vacuum, to center the cathode beam on the target; *n*, sylphon tube and *k*, nut, which permit adjustment of the filament relative to the focusing cup, likewise without breaking the vacuum; *w*, wax which is heated for removal of filament assembly *C*. Details of filament supporting cathode end; *m*, filament containing molybdenum cylinder, which fits loosely in the surrounding copper support; *c*, focusing cup. (Published through courtesy of Memorial Hospital, New York City).

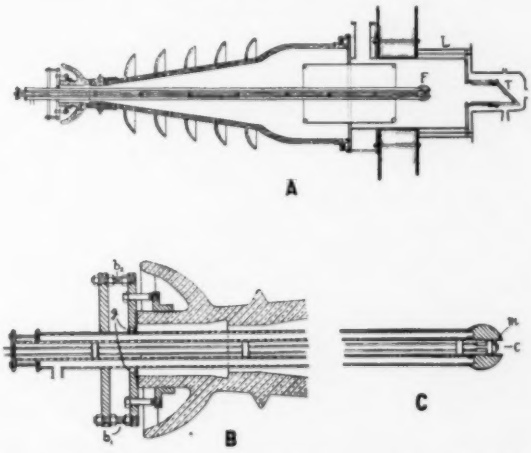


Fig. 2. Unisectional anode grounded porcelain roentgen tube (Harper Hospital). *A* showing ensemble of tube and filament target relation. *F*, filament; *T*, target; *L*, protective sheet lead envelope. *B*. Details of cathode adjuster. *g*, flexible copper gasket ring and $b_1$, $b_2$ ($b_3$ and $b_4$ not shown in diagram) adjusting bolts permitting the centering with respect to the axis of the tube of the filament supporting cathode stem, which is a long metal cylinder traversing the entire tube, without breaking the vacuum. *C*. Details of filament supporting cathode end. *m*, filament holder surrounded by steel support, *c*, focusing orifice. The focusing is done by changing the shape and depth of the filament within the cathode cup and by varying the size of the cathode orifice, after removing the head of the tube.

said that the distance between the filament containing cathode and the target in these tubes is from 1 to 3 feet, depending on the voltage range for which they are constructed. Although this distance is considerably shorter than the path in the multisectional tubes, nevertheless a certain amount of divergence of the cathode-ray beam takes place which in some instances may prove very disturbing. In most of these types of tubes used for general therapy at the present time, the

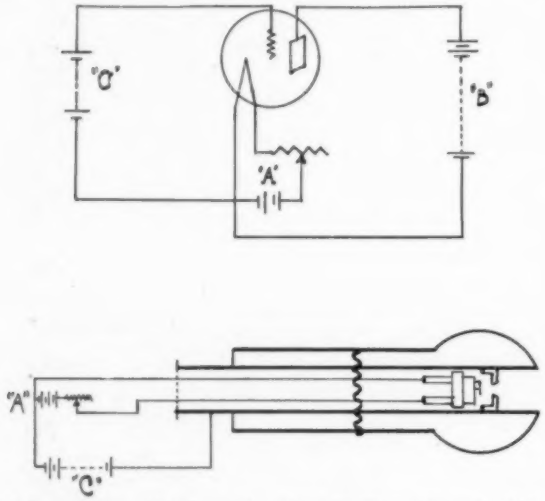


FIG. 3. Top, diagram showing DeForest's principle of the radio tube. Bottom, the same principle applied to control cathode-ray emission in a super-high voltage roentgen tube.

configuration of the focal spot is made a function of factors of design, such as shape of filament, numbers of turn of filament wire, depth of the filament within the cathode cup, size of the cathode cup, etc. Obviously a change in any of the parts is followed by a change in the focal spot with possible disturbance of the uniformity of the radiation field.

Because of the difficulty with which the uniformity of the field is re-established in such instances and because of other reasons we lately applied DeForest's principle[2] of the radio tube (Fig. 3) to obtain a better control of the cathode-ray emission and thus of the focal spot. As is known, the radio tube consists essentially of three parts (Fig. 3): a filament which is heated by an "A" battery and gives off electrons due to the "Edison effect." These electrons are accelerated toward the plate by a higher voltage, the "working potential" or "B" battery, which impresses a negative potential on the filament and a positive one on the plate. The stream of electrons between these two would then result in a constant flow of current for any given "B" potential and any fixed temperature of the filament. Between the filament and the plate, however, is interposed the "grid" which is the regulating element and which is activated by what we may call the "regulating potential." In radio the variation of this potential with the incoming signal determines the amount of current which will flow from filament to plate and hence the intensity of the sound. By interposing a regulating potential in the path of the cathode-ray beam of a roentgen tube in a similar manner we are able to regulate to a certain extent the flow of the electrons but most important of all we obtain a very good control of the focal spot. Figure 3 shows the parts of this arrangement as applied in our roentgen tube at Harper Hospital consisting essentially of the same three parts of the radio tube, connected in the same way. Briefly, the focal spot size is controlled by having the cathode beam emerge from an orifice three-eights of an inch in diameter, set one and five-eighths inches back of the face of the cathode. These dimensions were arrived at experimentally and were chosen because they give the most desirable focal spot at practical controlling voltages in a tube having a 20 inch focus distance, as our tube has. In applying the same cathode to a tube of different dimensions either these dimensions or the grid voltage might have to be varied. The filament is set 11 mm. (about three-eighths of an inch) behind the grid and consists of a perfectly flat spiral of tungsten wire. Under ordinary conditions a potential of about 90 volts exists between this spiral and the grid, hence the electrons thrown off by the filament are immediately accelerated toward the grid

in straight lines. Those striking the grid constitute a current flowing in the "C" battery circuit, those passing through the hole in the grid continue with their constant velocity out of the end of the cathode tube have a component of velocity perpendicular to the field and hence are bent back in a curved path toward the tube axis. In this way the amount of current passing through the tube and the size of

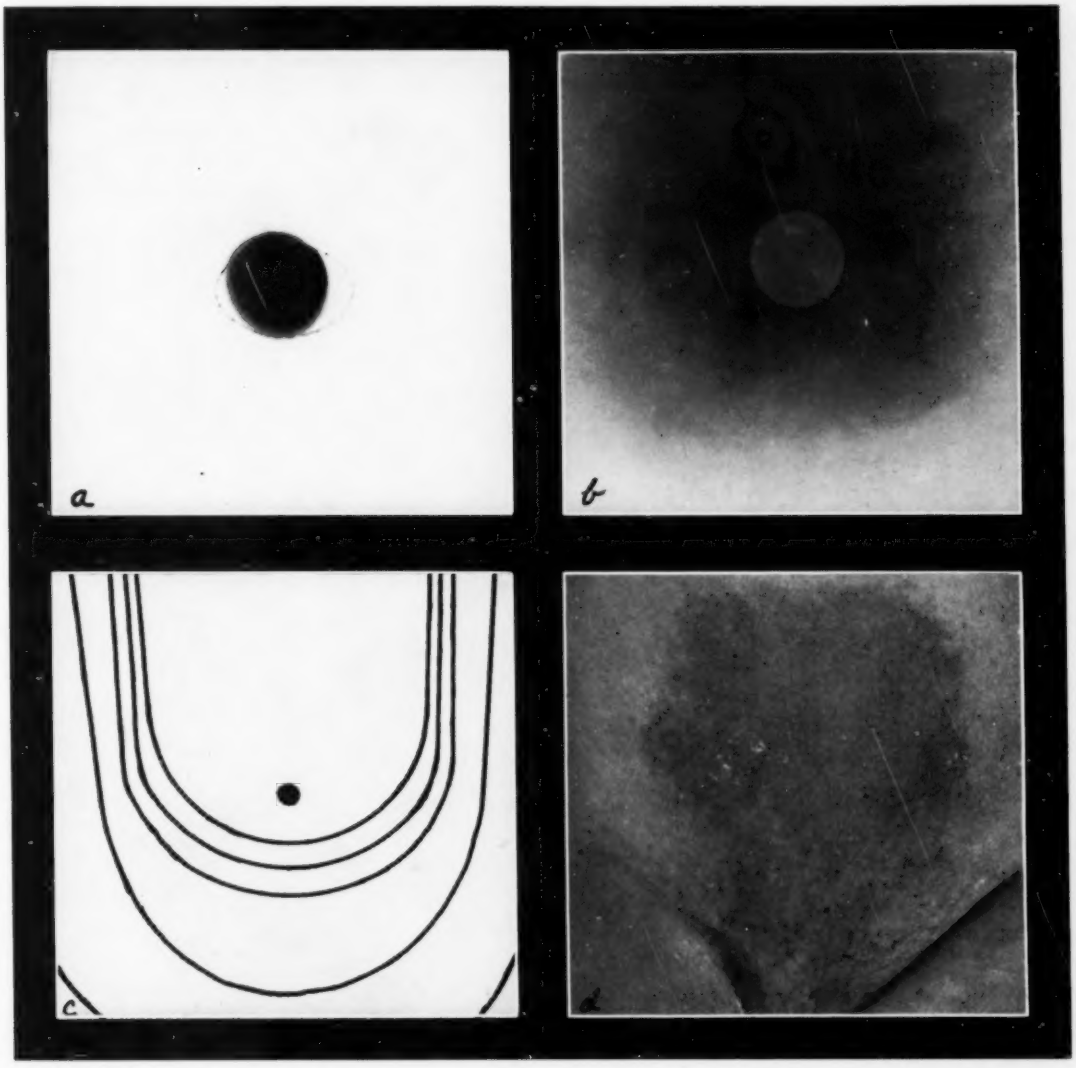


Fig. 4. Off center position of radiation field. *a*, pinhole camera picture of focal spot; *b*, roentgen photography of field; *c*, ionization map indicating the surface isodose curves, the difference between the individual curves amounting to 10 per cent when the central point is 100 per cent s.u.d.; *d*, actual erythema on a patient. (Note: the radiation fields in all illustrations are 20×20 cm. and the focal spots represent their true relative size.)

and into the electrostatic field existing between cathode and target. Here they are influenced in two ways. They are accelerated toward the target by the voltage on the tube, and those having a path which deviates somewhat from the axis of the the focal spot are brought under control by the potential applied to this grid. It is also obvious that all of the electrons escaping from the filament wire are given an acceleration toward the grid and that by proper shielding of the filament nearly all

of them can be made to pass out through the opening. Hence it is no longer necessary to run the filament at very high temperatures and the filament can be made to last for a long time.

(1) Off center position of the field. If the focal spot instead of being in the center is projected somewhere on the periphery of the target disk or even on the surrounding metal support, the roentgen beam will

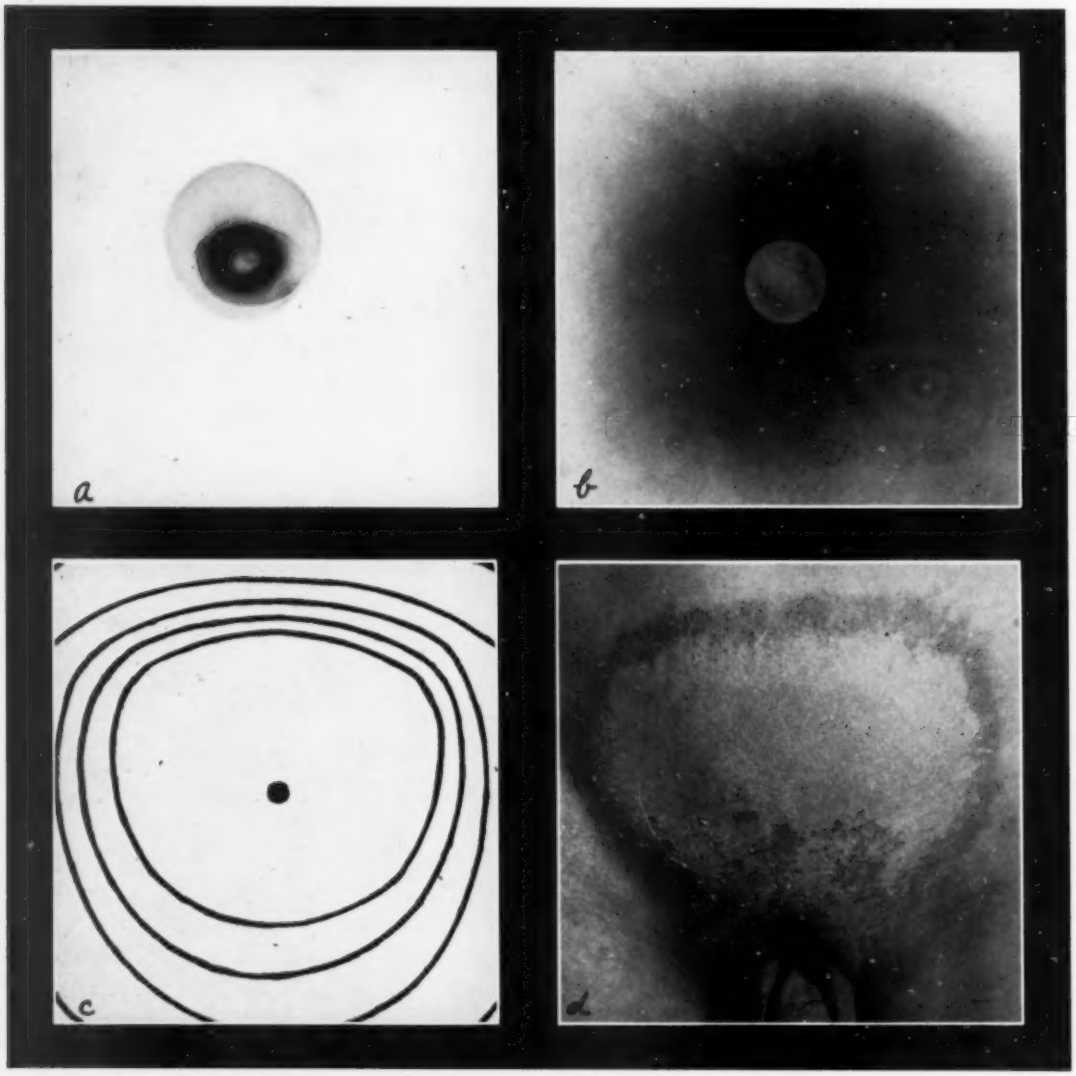


FIG. 5. Axial concentration of radiation field. *a*, pinhole camera picture of focal spot which is too broad; *b*, roentgen photography of field; *c*, ionization map, the difference between center and periphery being more than 40 per cent S.U.D.; *d*, actual erythema on patient, there being desquamation in the central portion and no erythema at the periphery of the field.

### TYPES OF DISTURBANCES OF THE UNIFORMITY OF THE RADIATION FIELD

In general, the disturbances in the uniformity of a radiation field may be classified as follows:

emerge under an angle which is off center in respect to the mid-point of the contemplated irradiation field (Fig. 4). This is due to various mechanical causes influencing the axis of the cathode-ray beam in its

relation to the axis of the tube, as, for example, deviation of the cathode-ray beam during its passage between the electrodes of the subsequent sections in the multisectional tube, tilting of the filament supporting cathode stem in the unisectional tubes, inclination of the filament wire plane, etc. To obviate or correct such occurrences, the tubes are provided with several adjusters (Figs. 1, B and 2, B) which permit the focusing of the cathode-ray beam on the center of the target, without breaking the vacuum of the tube.

(2) Axial concentration of the radiation field. Normally the distribution of the intensity in a radiation field is such that the central ray shows the greatest intensity and from this point there is a gradual decrease toward the periphery of the field, the difference not exceeding 10 per cent.

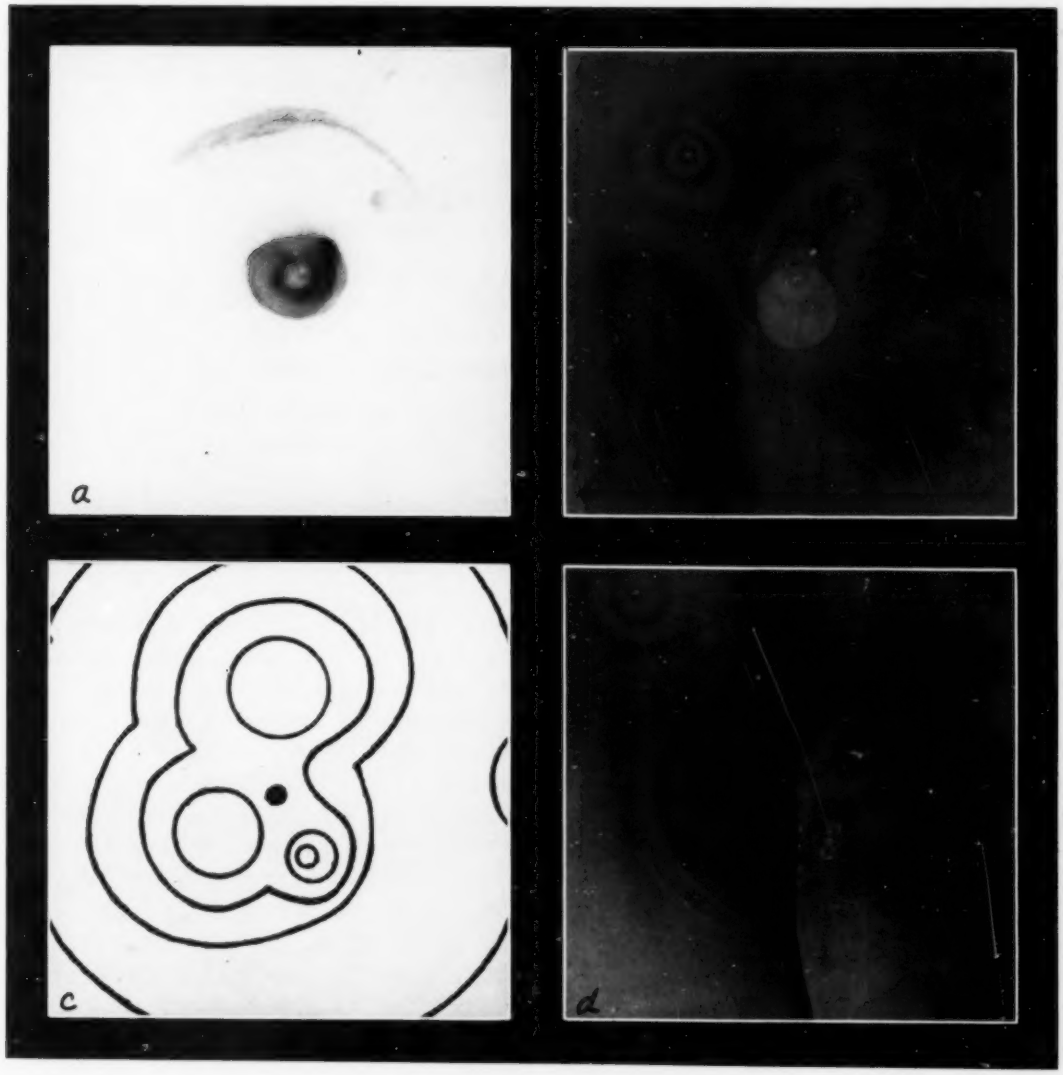


Fig. 6. Astigmatism of radiation field. *a*, pinhole camera picture of focal spot which shows unevenness; *b*, roentgen photography of field; *c*, ionization map, showing three astigmatic points, the difference between the strongest and weakest point of the field being more than 60 per cent S.U.D.; *d*, actual erythema on patient, showing second degree at one of the astigmatic points and no erythema in other parts of the field.

If, however, the focal spot is too diffuse, the emanating roentgen beam will show a comparatively greater intensity in the midportion than at the periphery, this resulting in an axial concentration of the radiation field. The axis of concentration may be in the center of the field or in any other place, in which case one may speak of an off center axially concentrated radiation field. Figure 5 shows, for example, an instance where the irradiation of a 20×20 cm. field resulted in a very remarkable axial concentration, there being a good second degree erythema in the axial portion and practically no erythema at the periphery. As is noted, the decrease of intensity toward the periphery occurs in a concentric manner, notwithstanding the fact that both the diaphragm of the roentgen beam and the limiting lead surrounding the field of irradiation were square. The correction is accomplished in the tube with magnetic focusing device by simply adjusting the focal spot and in the others by making constructional changes of the filament element. In our case, the focal spot, as already mentioned, is controlled by the size of the orifice of the cathode cup from which the cathode beam emerges and by the voltage of the accessory "C" circuit.

(3) Astigmatism of the field. If the focal spot is uneven or if an even focal spot bombards an uneven target, the emerging roentgen beam will have an irregular intensity distribution leading to astigmatism of the radiation field (Fig. 6). As can be seen, the main cause for such a disturbance lies either in the configuration of the filament or in the condition of the target. Unfortunately, both of these factors may suffer alteration during the course of the operation of the machine—sometimes in a practically imperceptible way to the operator—so that the danger of injury from them is not altogether small. In reference to the first, we observe, for example, that short circuiting of a helical filament wire or cold emission spots on any type of filament wire or on the supporting cathode stem may disturb the cathode-ray emission to such an extent that a very uneven focal spot is obtained. As to the second, we find that a too sharply focused or too concentrated cathode-ray beam at the target or a poor and uneven heat dissipation of the target supporting material, especially in case of a rich bombardment from stray electrons, or finally other causes having to do with the off center position and electrostatic distortion of the cathode-ray beam, may put such a stress on the target, which usually is very thin, that this develops an uneven surface and even breaks, giving rise to a roentgen beam of very irregular distribution. To eliminate such a source of disturbance often a complete replacement or rebuilding of the filament target elements is necessary.

## METHODS OF CONTROL OF THE RADIATION FIELD

Obviously it is impossible to correctly administer a certain prescribed radiation dose when the radiation field is affected with any of the above mentioned disturbances. But apart from this, a source of great danger lies in the fact that if the intensity measurements are made in a weaker part of the field, the stronger parts will form the seat of such an excessive amount of radiation as to produce severe and permanent injury to the tissues. Especially is this true when several fields are used for the purpose of crossfiring of a deep-seated lesion. At the intersection of the stronger parts the energy delivered will assume such formidable proportions that its damaging effect on the more sensitive structures as, for example, bowels, bladder, larynx, lungs, etc., cannot be underestimated. Moreover, one will gain the impression that the irradiation with superhigh voltages as a whole leads to capricious tissue reaction and to very unstable or even injurious therapeutic results and that, above all, the technique of its administration is exceedingly difficult to control.

There are three methods which may be used advantageously to estimate the uniformity of a radiation field:

(*a*) Pinhole camera pictures. These give information concerning three major factors which indirectly are responsible for the above mentioned disturbances: (1) Position of the focal spot in relation to the center of the target, indicating whether the cathode-ray beam strikes the target centrally or off center. The former results in a good projection of the roentgen beam (Fig. 7, *a*) whereas the latter not infrequently leads to an off center radiation field (Fig. 4, *a*). The varying angulation of the target in respect to the axis of the cathode-ray beam which despite a central location of the focal spot may produce an off center position of the radiation field (due to too much angulation) is a matter of tube design and therefore does not enter our consideration here. (2) Size and shape of the focal spot. It appears that in the tubes referred

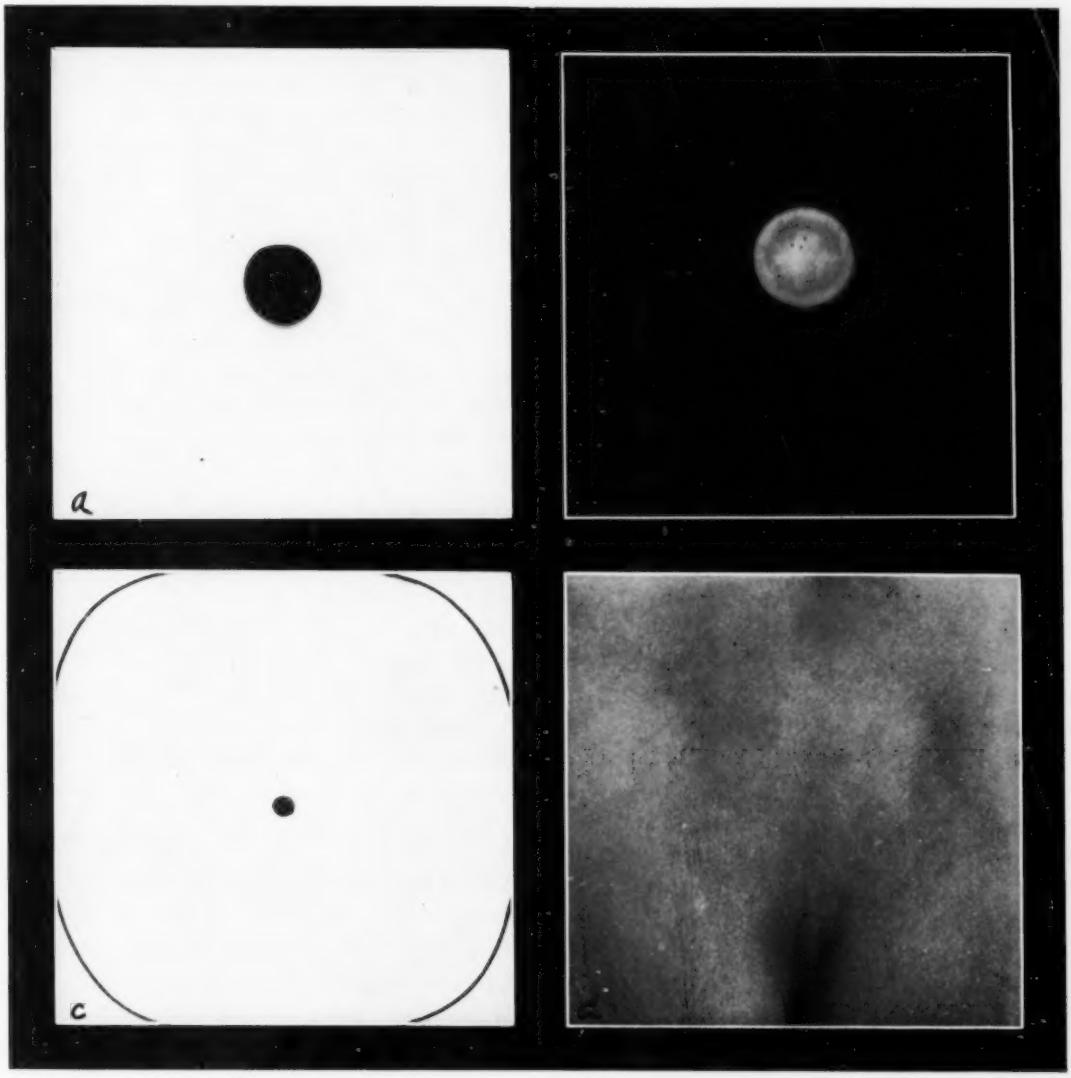


Fig. 7. Normal radiation field. *a*, pinhole camera picture of focal spot which is regular and has a uniform energy distribution; *b*, roentgen photography of field; *c*, ionization map showing less than 10 per cent difference between center and periphery except the corners of the field where there is a slight camera effect from the diaphragm which is square; *d*, actual erythema on a patient showing uniform distribution throughout the irradiated field.

to, a focal spot 1 to 4 cm. broad (of rounded, oval or elliptoid shape) constitutes the most effective area for the bombardment of the cathode rays, leading to a uniform distribution of the emanating roentgen beam. A finer focus would produce, no doubt, a better uniformity of the radiation but it would so overload the target as to damage or even ruin it, this, then, leading to all sorts of hazards. On the other hand, a too broad focal spot would result in such a great diffusion of the cathode-ray bombardment that the target supporting material would also become a source of roentgen emission, surrounding the original beam with a halo of softer radiation. Moreover, as already mentioned, it is observed that a too widely diffused area of cathode-ray bombardment leads to an axial concentration of the radiation field (Fig. 5, *a*). (3) Energy distribution of the focal spot. The variation in the energy distribution of the cathode rays when striking the target forms the most important source of astigmatism (Fig. 6, *a*) in the radiation field. To obtain the greatest uniformity of a radiation field, the focal spot must show a uniform energy distribution throughout (Fig. 7, *a*).

(*b*) Photography of the field. Roentgen photography of the radiation field—with or without intensifying screens—is of great value in permitting a rough topographic estimation of the field distribution (Figs. 4, 5, 6, 7, *b*). It is not proposed that the photographic method be used for the precise measurement of the difference of intensity of the various portions of the field, although such a method may eventually be feasible, despite the many obstacles which confront the investigator at the present time. It is only recommended that simple roentgen photographs be made at the point of emergence of the roentgen beam from the diaphragm and on the patient as a preliminary step to the mapping out of the radiation field by the ionometric method.

(*c*) Ionometric mapping of the radiation field. This constitutes, no doubt, the most important of all methods of field control. Since measurements must be carried out at very close points in the field small ionization chambers will best serve the purpose. If the intensity of the central ray is once measured by a standardized ionometer in roentgens, the rest of the field can be surveyed with a very small ionization chamber or a point chamber connected to an arbitrary measuring instrument, the difference of intensity being all that counts. The points of equal intensity are then connected and thus the entire field mapped out in surface isodose curves (Figs. 4, 5, 6, 7, *c*).

There is a fourth method of estimating the intensity distribution of a radiation field, namely, the observation of the erythema, but this must be used only after all physical methods have been ascertained and even then with exceedingly great care because of the dangers of injury to the patient. It is our own practice to determine the uniformity of the radiation field by the above three methods after every major change in the apparatus, then to treat one single area on the patient and wait three weeks until the erythema has developed. If a uniform erythema (Fig. 7, *d*) is obtained, confirming the physical measurements, irradiation is taken up routinely.

## SUMMARY AND CONCLUSIONS

The problems of uniform field distribution assume great practical importance in superhigh voltage roentgen therapy with tubes operating on a continuous pump. There are three possible major disturbances which may lead to a non-uniformity of the field intensity: (1) the off center position; (2) the axial concentration, and (3) the astigmatism of the applied roentgen beam. The non-uniformity due to any one of these disturbances may be so pronounced that a second degree erythema may appear in some sections and no erythema in other sections of the same irradiated field. Obviously, it becomes a practical impossibility to evaluate a given dose when working with such fields and

crossfiring with several fields may result in some very serious and permanent damage to the normal tissues. By disregarding the problem of field analysis, superhigh voltage roentgen therapy may appear capricious in its effect, inconclusive in its results and, above all, dangerous in its application. Apart from the constructional specifications—which are beyond the scope of this paper—it is recommended that the intensity distribution of the radiation field be controlled regularly by (*a*) pinhole camera pictures, (*b*) roentgen photography of the field and (*c*) ionization maps indicating the surface isodose curves. After ascertaining that the intensity is uniform throughout, a patient is irradiated with one single field by administering 100 per cent S.U.D. If a uniform erythema is obtained in three weeks, routine irradiation is started, the field being then checked in conjunction with other standardized measurements daily or, with some apparatus, several times during the same day.

## REFERENCES

1. Coolidge, W. D., Dempster, L. E., and Tanis, Jr., H. E. A high voltage induction coil and cascade tube roentgen-ray outfit. Am. J. Roentgenol. & Rad. Therapy, 1932, *27*, 405–414.
2. DeForest, B. *Patent Office Records*, 1911, *161*, 187.
3. Leucutia, T., and Corrigan, K. E. The present status of roentgen therapy with voltages above 200 kv. Am. J. Roentgenol. & Rad. Therapy, 1934, *31*, 628–662.

## DISCUSSION OF SYMPOSIUM ON SUPERVOLTAGE THERAPY*

Dr. H. Schmitz, Chicago. It is timely to have a discussion on the various ultra-high kilovolt transformers and roentgen tubes on account of the varying construction of the transformers, the varying currents and the varying types of tubes. However, it is as yet premature to compare clinical results or to acclaim better results for a given technique in comparison to others.

Three or five years hence the various investigators may again assemble, present the techniques used and the clinical data obtained and then decide whether our present technique with 200 kv. suffices or whether ultra-high voltage roentgen rays from a definite kilovoltage will give better results in the treatment of massive and deep cancers.

The motive evidently is to find out whether expensive radium bombs could be replaced with the more intense high voltage roentgen rays to obviate the enormous investments in capital and to overcome the impossibility of obtaining the large amounts of radium necessary in distant radiation, which simply do not exist and could not be procured probably within twenty years.

The immediate effects of roentgen rays on tissues, of course, may be discussed now and Doctors Murphy and Herendeen deserve our thanks in discussing the factors of treatment, the doses used and the early reactions on tissues. In the evaluation of such observations the wave lengths and the radiation doses should be considered. They depend on the factors used. With 800 kv. max. from a pulsating current, 10 ma., a focal skin distance of 70 cm., a field of 400 to 625 sq. cm. and a filter of 1.5 cm. water, 3 mm. aluminum, 3 mm. lead, 3 mm. Cu and 5 mm. bakelite we obtain an output of 28 r in air per minute. The tolerance dose is 2,500 to 2,800 r per field, attained with ten fractions within twenty-one to twenty-eight days. The depth dose at 10 cm. is about 50 per cent of the surface dose. The half-value layer is 7.6 mm. Cu, and the absorption curve forms practically a straight line. The tissue changes at 10 cm., using anterior and posterior fields, are as intense as at the skin surface. The result is that the combined method of radium and roentgen treatment of deep uterine cancers has been changed to a purely roentgen method without the use of radium or radon. Only exceptionally is a gamma dose of 1,200 to 1,800 mg-el-hr. added in the uterine cervix and none in oral, laryngeal, bladder and rectal carcinomas.

The high voltage roentgen-ray protection has been solved in a very economical way. Using an anode grounding, a grounded lead shield was placed close to the target end of the tube with a wall thickness of 15 cm. Seven tons of lead around the anode did the protection work that otherwise would have required about 120 tons of lead. In addition, 22 tons of lead are used around the treatment cubicle and another 12 tons in the floors and ceilings. Thus the safest protection at the least cost was procured. The daily use of protectometers, r-meters, photo-

* Papers of Drs. Murphy, Herendeen, and Leucutia and Corrigan.

graphic films about the treatment room and on the personnel demonstrates the complete safety from stray radiations. The lead protection also saves space in the building as heavy and massive concrete walls are not needed.

The tube has adjustable cathodes, mid voltage electrodes to concentrate the cathode-ray stream and magnetic focusing coils near the anodes. The dangers mentioned by Leucutia and Corrigan are real and make scientific work impossible at present. They are caused by very badly angled, irregular-sized or grossly uneven focal spots. These possibilities were foreseen and the regulating devices were installed to keep the size and position of the focal spot constant and controlled by the use of a pinhole camera device, magnetic focusing and so forth. This control may be had at all times with very little loss of time. Only twice during one year was it necessary to regulate the focal spot. The efficient water cooling of the target and target end, of course, means better life of the target and lesser changes in the focal spot.

The skin reactions observed in more than 800 patients concur with this statement.

Roentgen sickness is seen less in voltages above 500 kv. Below this as frequent with 200 kv.

DR. OTTO GLASSER, Cleveland, Ohio. I enjoyed these papers on supervoltage therapy immensely. Dr. Schmitz in his discussion has covered practically all the points of interest on this subject and so there is little left for me to say.

My own modest acquaintance with high voltage equipment consists of some experimental work on two 400 kv. installations, the tubes of both of which were operated at around 300 kv. One of these installations is that which Dr. Murphy has just described. He operated his tube at about 325 kv., I believe. Furthermore, we have been interested in supervoltage for about a year because we hope to be able to acquire a high voltage apparatus ourselves. We obtained from all the manufacturers in this country and abroad complete data on the various types of apparatus and all the institutions in which there is high voltage equipment kindly furnished us with data on their observations to date.

Looking into the question of the desirability of high voltage therapy, it seems to me that there is a rather unfortunate desire at the present time to jump to higher and higher voltages, or at least to discuss higher and higher voltages. If one clinic installs an apparatus of 600 kilovolts, another institution wants to compete and installs a 700 kilovolt apparatus. The next doctor wants one of a million volts and then the next is not satisfied with a voltage of less than a million and a half.

As has been said, this is unfortunate for two reasons: one is that we do not yet know which voltage range is the most desirable for practical therapeutic purposes; the other is that voltage specification alone does not tell the whole story. Dr. Schmitz has just explained why different tubes, different transformers, etc., produce different roentgen-ray beams, and I feel that we should use a more explicit term than kilovoltage to compare the quality or penetration of these short wave radiations. I am quite sure an induction current will not yield the same average wave length at 700 kv. as that produced by a constant potential or polyphasing machine.

Another important point in this connection is that if the voltage is increased, there is naturally an increase in all the difficulties which are encountered in the work with high voltage roentgen equipment. Dr. Leucutia and Dr. Corrigan have demonstrated an excellent piece of work which illustrates a real danger that existed in their apparatus. They discovered the disagreeable effects of irregular intensity distribution within the roentgen-ray field and abolished them. But if one who is not a good physicist or has not one at hand should obtain such an apparatus, he probably would run into serious difficulties.

Another thing that has to be considered in connection with the desire for higher voltage therapy apparatus is the economic factor. The higher the voltage, the more expensive the apparatus, and the more protection required against radiation and against high voltage electricity. In other words, the cost of installation and maintenance mounts rapidly as the voltage is increased.

Taking all these points into consideration, it seems to me that we have to come to some compromise. I personally feel that this whole question of supervoltage therapy will probably solve itself in the construction and adoption of sealed tubes to be run at around 500 kv. I do not believe that continuously evacuated tubes will be the final answer to practical high voltage therapy. Tubes with pumps probably will continue to be used in large institutions where

such apparatus can be cared for properly, but in average clinical work, sealed tubes will be used.

As mentioned before, I think that the voltage limit will be around 500 kv. Properly selected filters will permit the production of a rather penetrating roentgen-ray beam down to an effective wave length around 0.04 Ångström which is better than the quality produced with some early high voltage tubes run at considerably higher voltages. Such equipment will provide the compromise between the desire for penetrating radiation and the practical and economic limitations of such an installation Our present knowledge of the dependence of the physical factors in the irradiated tissue, such as absorption, scattering, etc., upon shorter wave length radiation as well as the meager clinical observations do not, in my opinion, warrant going beyond the limits just described.

Dr. T. Leucutia, Detroit, Mich. Dr.Corrigan has presented the physical part of the installation and from what was said, one might gain the impression that from the clinical standpoint the emphasis is not very great. Because of lack of statistical documentation for the present, one might even be tempted to conclude that superhigh voltage roentgen therapy will soon pass into a period of despair similar to that observed following the first enthusiastic establishment of deep roentgen therapy.

Obviously, it remains for the future to have this point proved. We can state, however, at the present that in a certain number of cases, perhaps 20 to 25 per cent of all malignancies, superhigh voltage roentgen therapy has already justified its usefulness. There are especially three reasons which account for this greater advantage: First, there is an increase of the differential action of the roentgen rays with increasing voltages. Whether this action is the result of better scattering and absorption characteristics or whether it is a direct, specific result does not matter. It remains a fact that there is a dependence on the selective function of the wave length which permits the administration of a proportionately larger dose.

Secondly, there is an increase in the total energy which can be delivered with higher voltages. If we take, for example, the 200 kv. (peak) apparatus and compare it with the 500 kv. (const.) apparatus, we will find that to produce an erythema with 200 kv. (peak) 600 r in air, or 900 r with back-scattering are required, whereas with 500 kv. (const.) we can administer 1,100 r in air or nearly 1,500 r with back-scattering to produce the same erythema, which means that we are able to almost double the dose which we can give over a certain area.

Thirdly, there is an increase in the depth dose with increasing voltages. It was brought out today that this dose increased anywhere from 40 per cent to 60 per cent 10 cm. below the surface of the skin.

Of course, the group of malignancies, as a whole, continues to be influenced by the same general laws of radiosensitivity as before, but within the groups themselves, the tumors, because of the above three biological advantages, show a certain increase in the irradiation response. We observe this, for example, in the group of carcinomas of the cervix, where it is reasonable to expect that the five year results will be increased at least 10 to 15 per cent, and the same applies also to certain other types of tumors.

To arrive at a conclusion we may say that superhigh voltage roentgen therapy, with certain restrictions and after elimination of the dangers which have been brought out today, will form a valuable addition to the therapeutic armamentarium in the treatment of malignancy.

Dr. G. Failla, New York City. I was not very much inclined to discuss this symposium because I feel the best thing to do at the present time is to await developments. The question of the selective action of the higher voltage radiation has been brought up and in this connection I would like to point out that there is at least one difference between the biological action of low voltage roentgen rays and high voltage roentgen rays, and that this difference is in the production of erythema. We all know that one can produce an erythema by means of ultraviolet light, in which case the radiation is absorbed completely in a very thin layer of skin. One can also produce an erythema by gamma rays, which are capable of passing through the patient with very little absorption. Now, what right have we to compare the erythema produced by ultraviolet light and the erythema produced by gamma rays, simply because both are capable of reddening the skin? If we attempt to compare the amount of energy that is required to produce this change in the appearance of the skin, we run into difficulties, because in one case the energy is absorbed in a very thin layer of skin, while

in the other case it is absorbed in a considerable thickness of tissue which directly or indirectly does produce the reddening of the skin. The same difficulty is involved in the comparison of erythemas produced by soft and hard roentgen rays, although to a smaller extent.

It is important to note that this problem cannot be solved by placing, say, *Drosophila* eggs or seeds on top of the skin and determining the effect on these organisms. The results thus obtained are due to the portion of the radiation which is absorbed in the organisms corresponding to a very superficial layer of skin, and not, in general, to the quantity and distribution of energy within the tissues, which are both responsible for the observed erythema. On account of the greater penetrating power of supervoltage roentgen rays and gamma rays, as well as the direct or indirect, but nevertheless real, increase in skin tolerance, one can deliver to a deep-seated tumor larger amounts of energy. Accordingly the therapeutic superiority of very hard roentgen rays and gamma rays in the treatment of deep-seated tumors can hardly be questioned.

In regard to the alleged absence of "radiation sickness" with supervoltage roentgen rays, I should like to point out that some patients get sick when they are treated with large quantities of radium at a distance. Therefore it is not a question of high voltage, since the quality of radiation emitted by the radium pack corresponds roughly to a roentgen tube voltage of 1,500 kv., which is higher than any used so far.

DR. HAROLD W. JACOX, Ann Arbor, Mich. May I ask Dr. Murphy what his minute intensity was with the 200 kv. so we can compare that with his minute intensity which was approximately 50 with his 300 kv. technique?

DR. MURPHY (closing). I will answer Dr. Jacox's question first. We used 200,000 volts with the 30 ma. tube, water-cooled. The roentgen emission of that technique at 50 cm. distance ran from 44 to 58 r per minute with different tubes so the doses are fairly comparable in roentgen rate of emission.

The discussion has been very interesting to me from the standpoint that this discussion always goes toward the physical side. I realize that many of these problems are physical ones, but I want to point out, as I tried to do in the paper, that if we are ever going to solve the cancer problem, we are going to solve it in many places in this country. I believe the physics of the machine will have to be done in the laboratory and the machine will have to be delivered to us as foolproof. The ordinary man in my position finds it impossible to have a physicist at his elbow all the time. We have to treat large numbers of patients who haven't much financial means.

Now with regard to the filtration. I think that is an extremely interesting matter. I have felt that we have had a different effect when we switched from copper to the Thoraeus filter. I have no proof of this as yet, but we are using the Thoraeus filter, which contains 0.4 mm. of tin, 0.25 mm. of copper and 1 mm. of aluminum. I would like to see some experimental work done on perhaps silver for a 400,000 volt tube. It just strikes me that that might be the filter that would be the most reliable. Dr. Glasser, however, is going to try some lead. I will be very glad to see that, because I think in that direction lies progress.

In the matter of protection, I agree that concrete is very good. In parts of the building above us where we have concrete floors, we had to use less lead protection. But I want to call attention to the trouble Dr. Hill had in Cleveland, where he thought he had 18 inches of concrete in an office building floor. He had a shell of concrete above and below filled with cinders. So be sure you have 18 inches of concrete when you think you have.

DR. CORRIGAN (closing). This problem of voltage versus filter was brought to the front. The question of comparing voltages is a very old one, probably as old as roentgen therapy, but in the range of very high voltage, of course, it assumes far greater importance than it does at 200 kv. or lower voltages. There is plenty of published work to point out that a sharp peaked high voltage such as the output of a spark coil, the sine wave of an alternating current machine or the straight line function of a constant potential machine are not immediately comparable. It is our impression that in any case where voltage is under discussion, the voltage published or discussed should be the effective voltage and not maximum spark gap voltage. On the question of filters, this of course is of very vital importance. We have looked upon our machine as more or less of an experimental installation. We repeatedly juggled the filters around and by so doing, we have changed our depth dose from about 53 per cent with the lead filter to about 48.2 per cent using filters consisting entirely of light elements. The filter in use at the present time is 7 mm. of steel, 2

mm. of aluminum, 3 mm. of celluloid, the secondary filter being directly on the patient's skin. It seems to us that it is not entirely desirable to filter the beam too highly. There is something involved other than pure depth dose and, as in filtering the cathode ray, a better technique must be used than just brute force to drive in a high depth dose.

On the question of pumps, I find I have to disagree with Dr. Glasser, although I dislike very much to do so. Pumps within the last couple of years have been very radically changed. At the present time, we are using a bank of pumps which operate on apiezon oil, which use no liquid air. I want to point out that these pumps are very, very fast. They are at least five times as fast as any type of pumps we ever had before, including mercury pumps, which we used to use. They will give us a vacuum from a dead start in about three hours. They will maintain that vacuum on the order of two or three times ten to the minus sixth indefinitely. So far as I can see, there is absolutely no worry about pumps at the present time.

The output of the tube in roentgens has been the subject of discussion here and I would like to point out that in our case we use at the present time a rather low output compared to the other gentlemen who have presented papers. It has been conclusively demonstrated over a period of about two years that our tube will operate at from 6 to 10 ma. However, at the present time we are using 3 ma. plus whatever leakage current there is, which amounts to a few tenths; and we are getting an output of 20 r per minute which for the time being is what we intend to apply to the patient. It is possible for us to get very much more than that, in fact, we can get about 53 r per minute.

It is practically impossible to puncture this type of tube. The only type of repair which is ever required by the tube is replacement of a burned-out filament and with the present cathode system, even this replacement is very rare indeed. As already pointed out, the cathode in our tube extends almost up to the base of the target which means it extends through the lead of the tube, all of which is grounded and all of which is protected with lead so there is practically no stray radiation produced outside the lead shield.

# FACTORS INFLUENCING THE QUANTITATIVE MEASUREMENT OF THE ROENTGEN-RAY ABSORPTION OF TOOTH SLABS*

## III. MECHANICAL FACTORS OF TUBE AND MACHINE

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IN CONSIDERING the variables which might influence the accuracy of the densitometric study of the dentine and enamel of the tooth slab,[1] it is important to consider the influence, if any, of tube and radiation factors, i.e., changes in the size of the focal spot from which the radiation originates, the focus-object-film distance, changes in exposure ($i \times t$) with both intensity and time varying, and the influence of the quality of the beam. These variables are discussed in sequence in the following pages, only sufficient data being given to establish for our purposes the degree of precision necessary for a given result. As stated before, scientific proof would entail a tremendous amount of amplification, which we deemed impracticable. Furthermore analysis of some of these problems from a geometric standpoint or from known data and from practical experience offers, together with the data which we present, sufficient basis for a working hypothesis.

### A. FOCUS

One of the factors which detracted from the precision of the method even with all the precautions and details considered[1] was the variation sometimes observed in the density readings (D.Rs.) from the left side of the left penetrometer directly across on the same step to the right side of the right penetrometer. The magnitude of this variation was often of the order of 0.10 to 0.20 density units. Although we recognized the inaccuracy introduced, our procedure was to take an average value of the readings from left to right and use the average in plotting the D-T curve (density-thickness). By eliminating this variation, i.e., using the uniform part of the beam from any focal spot the error (standard deviation) was reduced from about 5 per cent to about 3 per cent.

Since the variation of D.R. seemed to be connected in a geometrical way with the field under the tube a series of exposures were made (see Fig. 11) with (1) the penetrometers at right angles to the long axis of the tube and vertically, i.e., lengthwise on the 5″×7″ film; (2) the penetrometer parallel to the long axis of the tube and horizontally (crosswise) on the film, and (3) the penetrometers parallel to the long axis of the tube and vertically (lengthwise) on the film. Since each film was developed with the right, i.e., notched,

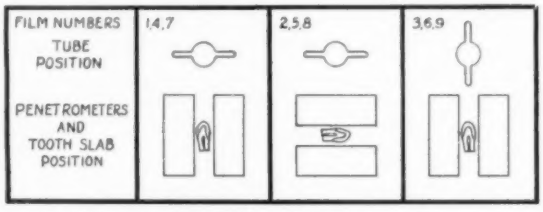
FILM NUMBERS
TUBE POSITION
PENETROMETERS AND TOOTH SLAB POSITION
1.4.7
2.5.8
3.6.9
TUBE TYPE :- 1- ROUND FOCUS, AIR COOLED - FILM Nos 1.2.3
2- LINE FOCUS, AIR COOLED - FILM Nos 4.5.6
3- LINE FOCUS, WATER COOLED - FILM Nos 7.8.9

FIG. 11. To compare geometrical gradients of energy output by round and line focus tubes, a series of exposures are made as illustrated. Since the notched edge of the film is always placed at the right hand side in each exposure and then the film is developed with the notched edge up, developmental differences are ruled out.

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†† Rockefeller Fellow in Dentistry.
[1] Warren, S. L. et al. A quantitative method for studying the roentgen-ray absorption of tooth slabs. AM. J. ROENTGENOL. & RAD. THERAPY, 1934, *31*, 663–672.

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TABLE XVII

ROUND FOCUS, AIR-COOLED TUBE, 30 KV., 15 INCHES, 30 MA., 0.85 SECOND, NO FILTER, BLACK PAPER-WRAPPED

| Film | 1 | | 2 | | 3 | |
|---|---|---|---|---|---|---|
| Densitometer Readings | | | | | | |
| *Penetrometer* | *Left* | *Right* | *Left* | *Right* | *Left* | *Right* |
| Step 1 | 1.63–1.62 | 1.62–1.61 | 1.62–1.62 | 1.65–1.66 | 1.57–1.57 | 1.59–1.60 |
| 2 | 1.28–1.28 | 1.28–1.27 | 1.31–1.32 | 1.32–1.32 | 1.24–1.26 | 1.28–1.28 |
| 3 | 1.04–1.04 | 1.06–1.05 | 1.06–1.07 | 1.08–1.07 | 1.07–1.07 | 1.08–1.05 |
| 4 | 0.86–0.88 | 0.89–0.87 | 0.89–0.89 | 0.91–0.89 | 0.88–0.89 | 0.88–0.89 |
| 5 | 0.74–0.74 | 0.75–0.74 | 0.74–0.75 | 0.75–0.76 | 0.74–0.75 | 0.75–0.74 |
| 6 | 0.59–0.62 | 0.63–0.64 | 0.64–0.64 | 0.63–0.66 | 0.64–0.65 | 0.63–0.65 |
| 7 | 0.52–0.55 | 0.54–0.56 | 0.55–0.57 | 0.55–0.59 | 0.55–0.55 | 0.55–0.55 |
| 8 | 0.48–0.51 | 0.52–0.52 | 0.51–0.52 | 0.50–0.51 | 0.53–0.54 | 0.52–0.53 |
| Enamel | 0.72 | | 0.72 | | 0.73 | |
| Dentine | 1.06 | | 1.04 | | 1.05 | |
| Interpolated Values | | | | | | |
| Enamel | 1.31 | | 1.27 | | 1.31 | |
| Dentine | 0.78 | | 0.83 | | 0.81 | |

edge up, developmental differences may be ruled out if the second and third exposures are found to give uniform readings across the step tablets. A series of films were made using (1) a round focus, air-cooled radiator type tube (G.E. 5–30); (2) a line focus, air-cooled radiator type tube (G.E. XPI), and (3) a line focus, water-cooled tube (G.E. $XP_4$).

In Table XVII are given the D.Rs. in the various steps of the penetrometers in 3 films taken as shown (Fig. 11, films 1, 2, 3), using a round focus, air-cooled tube at 30 kv., 15 inches, 30 ma., no tube stand filter, paper-wrapped films and 0.85 second exposure. The D-T curves (not shown) are fairly low in the density range yet have a typical slope and are closely interlaid. The I.Vs. for the enamel are about 1.3 mm. Al, for the dentine about 0.8 mm. Al; i.e., values typical in every respect.

In Table XVIII are given the D.Rs. in the various steps of the penetrometers in 3 films taken as shown (Fig. 11, films, 4, 5, 6), using a line focus, air-cooled tube at 30 kv., 15 inches, 30 ma., no filter, paper-wrapped films and 0.85

TABLE XVIII

LINE FOCUS, AIR-COOLED TUBE, 30 KV., 15 INCHES, 30 MA., 0.85 SECOND, NO FILTER, BLACK PAPER-WRAPED

| Film | 4 | | 5 | | 6 | |
|---|---|---|---|---|---|---|
| Densitometer Readings | | | | | | |
| *Penetrometer* | *Left* | *Right* | *Left* | *Right* | *Left* | *Right* |
| Step 1 | 1.27–1.25–1.24 | 1.16–1.15–1.09 | 1.21–1.20 | 1.20–1.17 | 1.08–1.08 | 1.09–1.08 |
| 2 | 1.02– 0.99 | 0.93– 0.90 | 0.97–0.96 | 0.96–0.94 | 0.90–0.90 | 0.89–0.88 |
| 3 | Not read | | 0.80–0.81 | 0.77–0.77 | 0.76–0.76 | 0.75–0.77 |
| 4 | | | 0.67–0.67 | 0.67–0.66 | 0.66–0.67 | 0.67–0.68 |
| 5 | | | 0.57–0.57 | 0.57–0.57 | 0.59–0.59 | 0.58–0.58 |
| 6 | | | 0.51–0.51 | 0.51–0.50 | 0.54–0.54 | 0.53–0.54 |
| 7 | | | 0.45–0.46 | 0.45–0.46 | 0.48–0.50 | 0.50–0.48 |
| 8 | | | 0.41–0.41 | 0.41–0.41 | 0.46–0.46 | 0.46–0.46 |
| Enamel | | | 0.55 | | 0.55 | |
| Dentine | | | 0.77 | | 0.73 | |
| Interpolated Values | | | | | | |
| Enamel | | | 1.35 | | 1.41 | |
| Dentine | | | 0.82 | | 0.85 | |

TABLE XIX

LINE FOCUS, WATER-COOLED TUBE, 30 KV., 15 INCHES, 30 MA., 0.85 SECOND, NO FILTER, BLACK PAPER-WRAPED

| Film | 7 | 8 | | 9 | |
|---|---|---|---|---|---|
| Densitometer Readings | | | | | |
| *Penetrometer* | *Left* | *Left* | *Right* | *Left* | *Right* |
| Step 1 | 1.11–1.11–1.08 | 1.10–1.09 | 1.07–1.08 | 1.21–1.23 | 1.24–1.23 |
| 2 | 0.88–0.87–0.87 | 0.88–0.87 | 0.87–0.85 | 1.00–1.00 | 1.00–1.01 |
| 3 | Not read | 0.73–0.73 | 0.71–0.70 | 0.85–0.84 | 0.86–0.87 |
| 4 | | 0.60–0.60 | 0.59–0.58 | 0.74–0.74 | 0.74–0.75 |
| 5 | | 0.51–0.51 | 0.50–0.50 | 0.66–0.65 | 0.66–0.66 |
| 6 | | 0.46–0.46 | 0.45–0.45 | 0.60–0.61 | 0.60–0.60 |
| 7 | | 0.43–0.41 | 0.43–0.41 | 0.54–0.57 | 0.55–0.54 |
| 8 | | 0.40–0.39 | 0.38–0.38 | 0.48–0.50 | 0.50–0.50 |
| Enamel | | 0.49 | | 0.60 | |
| Dentine | | 0.72 | | 0.84 | |
| Interpolated Values | | | | | |
| Enamel | | 1.32 | | 1.48 | |
| Dentine | | 0.78 | | 0.81 | |

second exposure. The D-T curves (not shown) are low in the density range, are horizontal and similar. The I.Vs. for the enamel are greater than 1.3 mm. Al, for the dentine are greater than 0.8 mm. Al, values in both cases higher than usual (see below).

In Table XIX are given the D.Rs. in the various steps of the penetrometers in 3 films taken as shown (Fig. 11, films, 7, 8, 9), using a line focus, water-cooled tube at 30 kv., 15 inches, 30 ma., no filter, paper-wrapped films and at 0.85 second exposure. The D-T curves (not shown) are much like those for the line focus, air-cooled tube (see Table XVIII), are low in the density range, horizontal and crossed. The I.Vs. for the enamel are greater than 1.3 mm. Al, for the dentine are about 0.8 mm. Al, similar to the interpolated values using the line focus, air cooled tube (see below).

The I.Vs. for the enamel and for the dentine using the line focus tubes are high, due to the horizontal position of the D-T curves which is typical of curves for short exposures (see III c). The error of interpolation is so great in horizontal D-T curves that the I.Vs. are not precise. The short exposures were necessary so as to permit D.Rs. in the film not under the penetrometers. Employing exposures of sufficient length to obtain D-T curves in the usual ranges, the usual slope is found and the I.Vs. become normal.

The D.Rs. in Step 1 of film 4 are 1.27, 1.25, 1.24, 1.16, 1.15, and 1.09, a decrease from left to right of 0.16 density units. In Step 2 of film 4, the D.Rs. are 1.02, 0.99, 0.93 and 0.90, a decrease of 0.12 density units. This film is exposed (Fig. 11) with the penetrometers at right angles to the long axis of the tube. Film

TABLE XX

DENSITOMETER READINGS IN THE FILM EXPOSED TO UNFILTERED RADIATION NEAR THE VARIOUS STEPS OF THE PENETROMETERS

| Film | 5 | | | | 6 | | | | 8 | | | | 9 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Densitometer Readings | | | | | | | | | | | | | | | | |
| *Penetrometer* | *Left* | | *Right* | | *Left* | | *Right* | | *Left* | | *Right* | | *Left* | | *Right* | |
| | *Left* | *Right* | *Left* | *Right* | *Left* | *Right* | *Left* | *Right* | *Left* | *Right* | *Left* | *Right* | *Left* | *Right* | *Left* | *Right* |
| Step 1 | 1.62 | 1.61 | 1.60 | 1.59 | 1.45 | 1.50 | 1.47 | 1.45 | 1.49 | 1.45 | 1.45 | 1.48 | 1.67 | 1.70 | 1.69 | 1.71 |
| 2 | 1.61 | 1.56 | 1.59 | 1.56 | 1.48 | 1.50 | 1.49 | 1.54 | 1.48 | 1.45 | 1.43 | 1.48 | 1.68 | 1.70 | 1.70 | 1.74 |
| 3 | 1.58 | 1.54 | 1.59 | 1.55 | 1.49 | 1.53 | 1.53 | 1.55 | 1.48 | 1.43 | 1.43 | 1.45 | 1.69 | 1.70 | 1.72 | 1.76 |
| 4 | 1.58 | 1.50 | 1.54 | 1.52 | 1.53 | 1.56 | 1.55 | 1.57 | 1.48 | 1.42 | 1.42 | 1.44 | 1.72 | 1.71 | 1.77 | 1.78 |
| 5 | 1.57 | 1.46 | 1.54 | 1.51 | 1.55 | 1.58 | 1.57 | 1.62 | 1.46 | 1.42 | 1.42 | 1.43 | 1.76 | 1.77 | 1.79 | 1.80 |
| 6 | 1.54 | 1.48 | 1.54 | 1.51 | 1.60 | 1.62 | 1.62 | 1.63 | 1.44 | 1.41 | 1.40 | 1.42 | 1.77 | 1.80 | 1.81 | 1.81 |
| 7 | 1.48 | 1.47 | 1.45 | 1.46 | 1.62 | 1.64 | 1.62 | 1.65 | 1.40 | 1.38 | 1.38 | 1.42 | 1.83 | 1.78 | 1.83 | 1.82 |
| 8 | 1.45 | 1.45 | 1.44 | 1.43 | 1.63 | 1.64 | 1.65 | 1.67 | 1.40 | 1.37 | 1.34 | 1.37 | 1.84 | 1.85 | 1.80 | 1.83 |

7 is also taken with the penetrometers at right angles to the long axis of the tube. The D.Rs. in film 7 in Step 1 decrease 0.13 density units, thus: 1.11, 1.11, 1.08, 1.05, 1.01, 0.98 from left to right; in Step 2 decrease 0.11 density units, thus: 0.88, 0.87, 0.87, 0.82, 0.80, 0.77 from left to right. Since similar gradients are not noted with the penetrometers parallel to the long axis of the tube (films, 2, 3, 5, 6, 8, 9), and since the position of the penetrometers on the film relative to the position in development has no effect in producing this gradient (film 5 vs. 6, 8 vs. 9) the gradient must represent a variation in the field of the line focus tubes. The reason that the gradient is most apparent in Step 1 and decreasingly apparent in the thicker steps may be found in the fact that about 50 per cent of the incident radiation is transmitted by Step 1 and less than 7 per cent by Step 8.

That a gradient exists in films 5, 6, 8, 9, although it is not evident from the D.Rs. in the penetrometer, may be seen by examining the data given in Table xx which records the densitometer readings *in the film exposed to unfiltered radiation* (*a*) at the left hand, (*b*) at the right hand end of each step of the left penetrometer, (*c*) at the left hand, (*d*) at the right hand end of each step of the right penetrometer in the films which were made with the line focus tubes (see Fig. 11). In film 5 a gradient is represented running *along* the penetrometer which differs by about 0.16 density units across the long axis of the penetrometer, in effect this means that Step 1 received a greater intensity of radiation than Step 8 in the ratio of 1.62 to 1.45. There is also a gradient from left to right of about 0.03 density units; this gradient may be noted in the regular diminution of D.Rs. across each step of the penetrometers from left to right (see film 8, Table xix, for example). Due to the small size of this gradient (about the difference measurable by the densitometer) its effect may be neglected. In films 6, 8 and 9, similar gradients along the long axis of the penetrometer may be seen amounting to about 0.20, 0.11 and 0.15 density units, respectively. The inference seems inescapable that this gradient represents too great a change in intensities to permit a high order of precision in I.Vs. Inasmuch as these films were taken at 15 inch target-film distance it is suggested that this distance be increased, thereby decreasing the gradient per unit distance on the film (see next section).

*Conclusion.* The presence of a gradient across the penetrometers results in an error in I.Vs. due to unequal amounts of radiation falling on the penetrometers and the teeth. On the other hand, a gradient along the penetrometers gives rise to a flattened or steepened D-T curve which will also result in erroneous I.Vs. Round focus tubes seem to introduce less error from this source than line focus tubes. Obviously a geometric study of the projected focal spot clarifies this problem since the "disc" from the round focus tube gives a more horizontal source for the same size and energy. Errors due to non-uniformity of radiation brought about by the focal spot shape and size may be avoided by the use of proper distance and centering.

### B. DISTANCE BETWEEN FILM AND TARGET

In order to test the independence of the I.Vs. for enamel and dentine in mm. Al when the film-target distance is varied from 15 to 60 inches (representing the limits for distance change in the tube stand used) a series of exposures are made at 15, 30, 45, and 60 inches, 30 kv., 30 ma. and at exposure times calculated from the inverse square relation to give approximately equal densities of the films. Other factors were maintained constant as nearly as possible. Since the films were enclosed in cardboard cassettes and the voltage was 30 kv., the I.Vs. for enamel are near 1.20 mm. Al, a phenomenon discussed under filters (see paper II, part B). The thickness of the object (tooth slab 0.7 mm.) is so small as to remove any relation of the target-object and object-film distances in this discussion. Penumbra effects will be discussed later.

In Table xxi are recorded the D.Rs. in the various steps of the penetrometers for 2 films taken at 15 inches, 2½ seconds, 30 kv., 30 ma. The D.Rs. vary in Step 1 to Step 8 from 2.62 to 0.43 in film A and from 2.54 to 0.39 in film B. The D-T curves (film A in Fig. 12) are logarithmic and similar to the curves for other distances. The D.Rs. in the enamel are 0.81 and 0.86, in the dentine 1.41 and 1.38 for films A and B, respectively. The I.Vs. for the enamel

TABLE XXI

15 INCHES, 2½ SECONDS, 30 KV., 30 MA.

| FILM | A | | B | |
|---|---|---|---|---|
| DENSITOMETER READINGS | | | | |
| *Penetrometer* | *Right* | *Left* | *Right* | *Left* |
| Step 1 | 2.62–2.57 | 2.52–2.47 | 2.54–2.50 | 2.40–2.38 |
| 2 | 1.86–1.89 | 1.83–1.75 | 1.79–1.78 | 1.79–1.79 |
| 3 | 1.39–1.39 | 1.35–1.30 | 1.35–1.35 | 1.31–1.33 |
| 4 | 1.00–1.03 | 1.03–1.01 | 0.99–1.01 | 0.99–0.97 |
| 5 | 0.78–0.75 | 0.77–0.77 | 0.73–0.79 | 0.76–0.75 |
| 6 | 0.62–0.59 | 0.56–0.59 | 0.57–0.58 | 0.59–0.58 |
| 7 | 0.48–0.49 | 0.47–0.46 | 0.45–0.49 | 0.47–0.49 |
| 8 | 0.43–0.43 | 0.43–0.44 | 0.40–0.39 | 0.42–0.46 |
| Enamel | —0.81 | | 0.86 | |
| Dentine | —1.41 | | 1.38 | |
| INTERPOLATED VALUES | | | | |
| Enamel | —1.22 | | 1.14 | |
| Dentine | —0.75 | | 0.76 | |

TABLE XXII

30 INCHES, 6 SECONDS, 30 KV., 30 MA.

| FILM | 12 | | 11 | | 13 | | 14 | | 15 | | 16 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EXPOSURE | | | | | | | | | | | | |
| DENSITOMETER READINGS | | | | | | | | | | | | |
| *Penetrometer* | *Right* | *Left* | *Right* | *Left* | *Right* | *Left* | *Right* | *Left* | *Right* | *Left* | *Right* | *Left* |
| Step 1 | 1.69 | 1.70 | 1.67 | 1.75 | 1.67 | 1.70 | 1.68 | 1.74 | 1.68 | 1.69 | 1.75 | 1.82 |
| 2 | 1.20 | 1.24 | 1.22 | 1.24 | 1.17 | 1.21 | 1.16 | 1.20 | 1.20 | 1.22 | 1.20 | 1.25 |
| 3 | 0.89 | 0.90 | 0.87 | 0.94 | 0.88 | 0.86 | 0.83 | 0.87 | 0.90 | 0.92 | 0.89 | 0.92 |
| 4 | 0.65 | 0.67 | 0.65 | 0.67 | 0.69 | 0.62 | 0.61 | 0.63 | 0.69 | 0.71 | 0.64 | 0.66 |
| 5 | 0.52 | 0.55 | 0.52 | 0.53 | 0.52 | 0.52 | 0.50 | 0.52 | 0.56 | 0.57 | 0.50 | 0.51 |
| 6 | 0.47 | 0.44 | 0.44 | 0.42 | 0.45 | 0.45 | 0.43 | 0.45 | 0.47 | 0.49 | 0.42 | 0.43 |
| 7 | 0.43 | 0.41 | 0.41 | 0.36 | 0.37 | 0.38 | 0.40 | 0.38 | 0.43 | 0.44 | 0.35 | 0.40 |
| 8 | 0.37 | 0.37 | 0.38 | 0.34 | 0.36 | 0.37 | 0.38 | 0.36 | 0.41 | 0.41 | 0.33 | 0.35 |
| Enamel | —0.57 | | 0.56 | | 0.55 | | 0.52 | | 0.56 | | 0.53 | |
| Dentine | —0.88 | | 0.87 | | 0.83 | | 0.83 | | 0.91 | | 0.87 | |
| Film | —2.72 | | 2.67 | | 2.68 | | 2.70 | | 2.72 | | 2.73 | |
| INTERPOLATED VALUES | | | | | | | | | | | | |
| Enamel | —1.21 | | 1.19 | | 1.23 | | 1.24 | | 1.27 | | 1.23 | |
| Dentine | —0.80 | | 0.79 | | 0.80 | | 0.78 | | 0.77 | | 0.78 | |

TABLE XXIII

45 INCHES, 22½ SECONDS, 30 KV., 30 MA.

| FILM | AA | | BA | |
|---|---|---|---|---|
| DENSITOMETER READINGS | | | | |
| *Penetrometer* | *Right* | *Left* | *Right* | *Left* |
| Step 1 | 2.11–2.09 | 2.10–2.06 | 2.03–2.04 | 1.98–1.95 |
| 2 | 1.54–1.49 | 1.50–1.45 | 1.44–1.44 | 1.43–1.41 |
| 3 | 1.18–1.15 | 1.07–1.08 | 1.07–1.07 | 1.05–1.05 |
| 4 | 0.86–0.86 | 0.80–0.80 | 0.79–0.78 | 0.75–0.75 |
| 5 | 0.61–0.62 | 0.60–0.60 | 0.59–0.58 | 0.60–0.64 |
| 6 | 0.50–0.52 | 0.49–0.52 | 0.46–0.46 | 0.45–0.51 |
| 7 | 0.40–0.44 | 0.41–0.41 | 0.37–0.41 | 0.41–0.43 |
| 8 | 0.37–0.37 | 0.37–0.38 | 0.34–0.38 | 0.35–0.37 |
| Enamel | —0.70 | | 0.63 | |
| Dentine | —1.10 | | 1.07 | |
| INTERPOLATED VALUES | | | | |
| Enamel | —1.14 | | 1.21 | |
| Dentine | —0.81 | | 0.78 | |

are 1.22 and 1.14 mm. Al, for the dentine are 0.75 and 0.76 mm. Al; these values are in satisfactory agreement.

In Table XXII are recorded the D.Rs. in the various steps of the penetrometers for 6 films taken at 30 inches, 6 seconds, 30 kv. and 30 ma. The D-T curves (film 12 in Fig. 12) are of similar logarithmic shape to the curves for the other distances. The I.Vs. in the enamel are 1.19, 1.21, 1.23, 1.24, 1.27 and 1.23 mm. Al, in the dentine 0.77, 0.78, 0.78, 0.79, 0.80, and 0.80 mm. Al for the films 11, 12, 13, 14, 15 and 16, respectively; these values are in satisfactory agreement among themselves and with values at other distances.

In Table XXIII are recorded the D.Rs. in the various steps of the penetrometers for the 2 films taken at 45 inches, 22½ seconds, 30 kv. and 30 ma. The D-T curves (for film AA shown in Fig. 12) are logarithmic and similar in shape to those for other distances. The I.Vs. for the enamel are 1.14 and 1.21 mm. Al, for the dentine are 0.81 and 0.78 mm. Al for films A and B respectively; values in satisfactory agreement.

In Table XXIV are recorded the D.Rs. in the various steps of the penetrometers for the 2 films taken at 60 inches, 40 seconds, 30 kv. and 30 ma. The D-T curves (for film AB in Fig. 12) are logarithmic and similar in shape to the curves for other distances. The I.Vs. for the enamel are 1.18 and 1.18 mm. Al, for the dentine 0.74 and 0.77 mm. Al for films A and B, respectively; values in satisfactory agreement.

By way of summary, a comparison of the I.Vs. for enamel and for dentine shows that there is no change over the film-target distance from 15 to 30 to 45 to 60 inches, keeping the kilovoltage and milliamperage constant and varying the exposure time to make films of approximately equal densities. The D-T curves are closely similar in shape and slope at any of these distances.

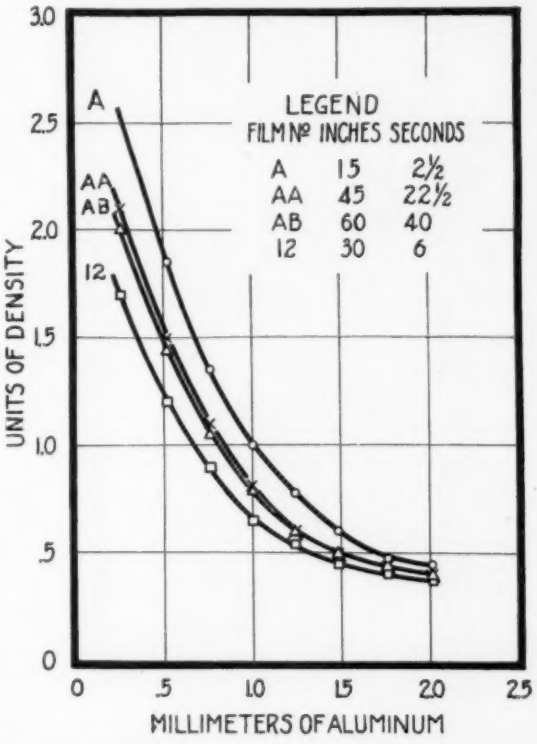



Fig. 12. To illustrate the independence of shape of D-T curves from change in target-film distance one film at 15, 30, 45 and 60 inches, respectively, is chosen and the D-T curves given here. The essential similarity of the D-T curves is evident.

It may be seen from Figure 12 that exposure

Table XXIV

60 inches, 40 seconds, 30 kv., 30 ma.

| Film | AB | | BB | |
|---|---|---|---|---|
| Densitometer Readings | | | | |
| *Penetrometer* | *Right* | *Left* | *Right* | *Left* |
| Step 1 | 2.02–1.99 | 1.98–1.92 | 1.98–1.95 | 1.97–1.99 |
| 2 | 1.43–1.43 | 1.43–1.37 | 1.41–1.41 | 1.41–1.40 |
| 3 | 1.11–1.09 | 1.04–1.04 | 1.04–1.03 | 1.04–1.05 |
| 4 | 0.85–0.81 | 0.78–0.79 | 0.79–0.79 | 0.77–0.78 |
| 5 | 0.67–0.66 | 0.59–0.58 | 0.64–0.64 | 0.60–0.62 |
| 6 | 0.52–0.55 | 0.49–0.49 | 0.49–0.51 | 0.49–0.49 |
| 7 | 0.43–0.44 | 0.41–0.42 | 0.43–0.43 | 0.41–0.43 |
| 8 | 0.37–0.37 | 0.39–0.40 | 0.36–0.40 | 0.40–0.41 |
| Enamel | —0.67 | | 0.67 | |
| Dentine | —1.14 | | 1.07 | |
| Interpolated Values | | | | |
| Enamel | —1.18 | | 1.18 | |
| Dentine | —0.74 | | 0.77 | |

TABLE XXV

20 KV., 15 MA., 30 INCHES, NO FILTER, BLACK PAPER

| FILM | 10336 | | 10337 | | 10338 | | 10339 | |
|---|---|---|---|---|---|---|---|---|
| EXPOSURE | 25 Seconds | | 20 Seconds | | 15 Seconds | | 10 Seconds | |
| DENSITOMETER READINGS | | | | | | | | |
| *Penetrometer* | *Left* | *Right* | *Left* | *Right* | *Left* | *Right* | *Left* | *Right* |
| Step 1 | 2.62–2.61–2.51 | 2.43–2.39–2.37 | 2.12–2.15–2.12 | 2.20–2.19–2.20 | 1.85–1.81–1.85 | 1.81–1.80–1.79 | 1.51–1.50–1.51 | 1.51–1.51–1.51 |
| 2 | 2.00–1.97–1.95 | 1.87–1.85–1.81 | 1.60–1.59–1.57 | 1.61–1.63–1.59 | 2.35–1.35–1.30 | 1.30–1.30–1.28 | 1.07–1.07–1.06 | 1.06–1.06–1.07 |
| 3 | 1.61–1.55–1.50 | 1.45–1.45–1.41 | 1.25–1.22–1.18 | 1.21–1.22–1.25 | 1.03–0.99–0.97 | 0.97–0.97–0.92 | 0.77–0.78–0.76 | 0.76–0.79–0.77 |
| 4 | 1.26–1.25–1.22 | 1.15–1.12–1.11 | 0.92–0.92–0.91 | 0.91–0.94–0.94 | 0.76–0.74–0.74 | 0.74–0.74–0.73 | 0.60–0.59–0.58 | 0.59–0.59–0.59 |
| 5 | 1.03–0.98–0.98 | 0.91–0.89–0.87 | 0.73–0.70–0.73 | 0.72–0.71–0.72 | 0.60–0.59–0.56 | 0.56–0.57–0.58 | 0.46–0.47–0.47 | 0.49–0.47–0.47 |
| 6 | 0.85–0.81–0.80 | 0.75–0.72–0.70 | 0.59–0.59–0.59 | 0.55–0.57–0.56 | 0.49–0.48–0.47 | 0.46–0.46–0.47 | 0.41–0.42–0.43 | 0.43–0.43–0.42 |
| 7 | 0.70–0.66–0.67 | 0.60–0.58–0.56 | 0.51–0.48–0.48 | 0.49–0.49–0.47 | 0.42–0.41–0.42 | 0.41–0.43–0.43 | 0.33–0.35–0.34 | 0.36–0.36–0.34 |
| 8 | 0.65–0.59–0.56 | 0.54–0.49–0.50 | 0.46–0.45–0.47 | 0.47–0.44–0.44 | 0.40–0.37–0.37 | 0.36–0.38–0.36 | 0.32–0.31–0.32 | 0.34–0.34–0.34 |
| Enamel | —0.83 | | 0.65 | | 0.54 | | 0.43 | |
| Dentine | —1.51 | | 1.19 | | 0.97 | | 0.80 | |
| INTERPOLATED VALUES | | | | | | | | |
| Enamel | | | 1.40 | | 1.34 | | 1.39 | |
| Dentine | | | 0.83 | | 0.79 | | 0.77 | |

times calculated from the inverse square law gave films of approximately equal densities. To avoid any gross compensating errors we thought it advisable to check the exposure values by an ionization method, being fully aware of the greater sensitivity of the film. Using a Victoreen r-meter, the output of the tube was measured by an exposure at 15 inches, 20 seconds, 30 kv., 30 ma., and found to be 36.7 r; by an exposure at 30 inches, 60 seconds, 30 kv. and 30 ma. and found to be 24.6 r. If the output at 15 inches is 36.7 r during 20 seconds, during 60 seconds it should be about $36.7 \times 3 = 110.1$ r. If the output in roentgens is inversely proportional to the distance squared, then $\frac{110.1}{24.6} = \frac{2^2}{1}$, since the distances are in exactly 2 to 1 ratio. Solving the equation 110.1 should equal $24.6 \times 4 = 108.4$; which is a satisfactory agreement, demonstrating that the output measured by an ionization method varies as the distance squared.

*Conclusion.* If the radiation per unit area is a function of the distance according to known laws, the I.Vs. should not depend upon the distance provided other factors are maintained constant; this is found to be the case as indicated both from the resulting film densities and from the interpolated values (I.Vs.) for enamel and dentine.

### C. VARIATION IN EXPOSURE TIME

In order to test the effect of varying the length of exposure time at various kilovoltages, other factors remaining constant, a series of exposures of 25, 20, 15, and 10 seconds were made at 20 kv.; of 25, 20 and 10 seconds at 25 kv.; of 10, 6, 5, 4, 3, 2 and 1 seconds at 30 kv.; of 2 and $1\frac{1}{2}$ seconds at 41 kv.; and of $2\frac{1}{2}$, 2, $1\frac{1}{2}$, 1, $\frac{1}{2}$ and $\frac{1}{4}$ seconds at 51 kv. Our earlier work was done at 51 kv. and our later experiments at 30 kv., hence the greater number of exposures at these kilovoltages. The D.Rs. are given below in Tables XXV–XXVIII, the D-T curves are shown and the results are discussed in connection with each table and chart.

In Table XXV are given the D.Rs. in the various steps of the penetrometers in 4 ex-

posures at 20 kv., 15 ma, 30 inches, no tube stand filter, black paper-wrapped films, and at 25, 20, 15 and 10 seconds. The D-T curves (Fig. 13) are typical, showing a fair regularity of density increase with increasing exposure time. The I.Vs. for the enamel range from 1.34 to 1.41 mm. Al; for the dentine from 0.77 to 0.83 mm. Al, values which are in fair agreement.

In Table xxvi are given the D.Rs. on the steps of the two penetrometers for films taken at 25 kv., 30 inches, 20 ma. and 25, 20, and 10 seconds' exposure. The logarithmic curves obtained (Fig. 14) by plotting D.Rs. against the appropriate thicknesses of each step as abscissae are smooth and possess a slope of approximately 45°. The I.Vs. for the enamel are 1.34, 1.41 and 1.34 mm. Al; for the dentine are 0.81, 0.78 and 0.81 mm. Al, respectively; values which have a satisfactory agreement.

In Table xxvii are recorded the D.Rs. obtained from 7 films taken at 30 kv., 30 inches, 30 ma. and 10, 6, 5, 4, 3, 2, and 1 seconds' exposure. The average D.Rs. in the various steps of the penetrometers are recorded, except in the case of the 10 second exposure. The obvious

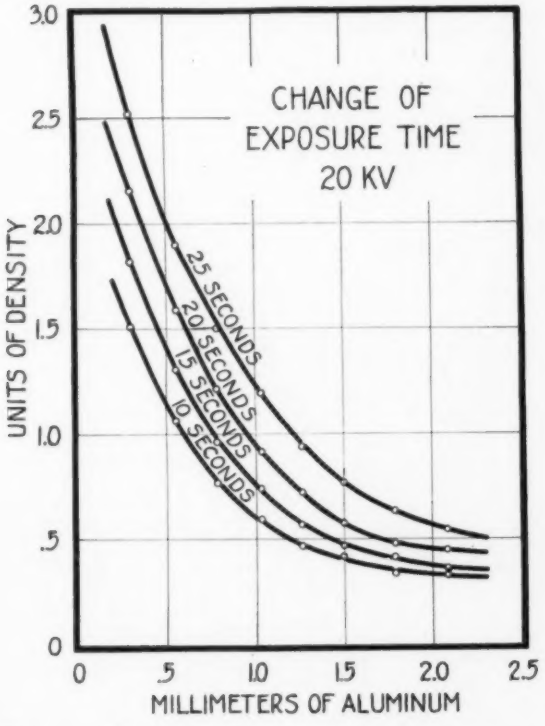



Fig. 13. The D-T curves for increasing exposure times have fairly regular increments. The shapes of the curves are similar and logarithmic.

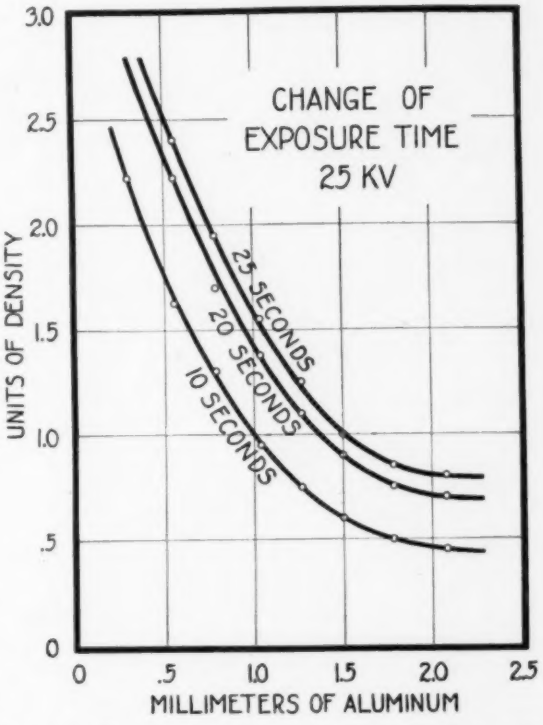



Fig. 14. The D-T curves at 25 kv. are similar to those at other kilovoltages and show increments with increasing exposure times (see Fig. 13).

constancy of D.R. shown for the 10 second exposure is characteristic of roentgenograms taken at the conditions stated as described in our discussion of the method, consequently the averages only are recorded for the shorter exposures. When the D.Rs. are plotted as ordinates against the appropriate thickness of step a series of logarithmic curves (Fig. 15) are described which vary by fairly regular increments of ordinates from the lowest curve (1 second) which is almost horizontal to the highest curve (6 seconds) which is inclined at approximately 45° to the axes. The I.Vs. in order of decreasing exposure time are 1.23, 1.20, 1.22, 1.05 and 1.25 mm. Al for the enamel and 0.73, 0.83, 0.81, 0.81, 0.86, and 1.00 mm. Al for the dentine. The variations in both enamel and dentine I.Vs. in the shortest exposures is due to the relatively horizontal character of the D-T curves. Otherwise the I.Vs. have a satisfactory degree of reproducibility.

In Table xxviii are recorded the D.Rs. in the various steps of the penetrometers in films at 41 kv., 30 inches, 2 and 1½ seconds' exposure. Logarithmic curves are obtained by plotting the D.Rs. as ordinates against the appropriate

TABLE XXVI

25 KV., 30 INCHES, 20 MA., NO FILTER, BLACK PAPER-WRAPPED

| FILM | 33E1 | | 33E2 | | 33E3 | |
|---|---|---|---|---|---|---|
| EXPOSURE | 25 Seconds | | 20 Seconds | | 10 Seconds | |
| DENSITOMETER READINGS | | | | | | |
| *Penetrometer* | *Right* | *Left* | *Right* | *Left* | *Right* | *Left* |
| Step 1 | 2.8 | 2.8 | 2.8 | 2.8 | 2.21–2.21 | 2.24–2.25 |
| 2 | 2.39–2.41–2.46 | 2.53–2.63–2.68 | 2.19–2.20–2.19 | 2.24–2.24–2.21 | 1.63–1.63 | 1.65–1.65 |
| 3 | 1.91–1.95–1.97 | 2.03–2.05–2.11 | 1.74–1.69–1.68 | 1.73–1.75–1.78 | 1.29–1.27 | 1.26–1.27 |
| 4 | 1.56–1.56–1.58 | 1.64–1.65–1.73 | 1.37–1.37–1.34 | 1.42–1.37–1.42 | 0.94–0.95 | 0.98–0.98 |
| 5 | 1.25–1.25–1.29 | 1.31–1.33–1.43 | 1.11–1.10–1.09 | 1.13–1.13–1.15 | 0.72–0.75 | 0.77–0.77 |
| 6 | 1.01–1.01–1.07 | 1.05–1.10–1.11 | 0.89–0.89–0.88 | 0.95–0.95–0.96 | 0.61–0.59 | 0.59–0.64 |
| 7 | 0.87–0.85–0.85 | 0.87–0.90–1.03 | 0.72–0.71–0.75 | 0.77–0.79–0.83 | 0.47–0.51 | 0.51–0.53 |
| 8 | 0.77–0.79–0.77 | 0.80–0.80–0.89 | 0.63–0.64–0.65 | 0.69–0.69–0.70 | 0.45–0.46 | 0.48–0.52 |
| Enamel | 1.21 | | 0.99 | | 0.69 | |
| Dentine | 1.98 | | 1.75 | | 1.24 | |
| INTERPOLATED VALUES | | | | | | |
| Enamel | 1.34 | | 1.41 | | 1.34 | |
| Dentine | 0.81 | | 0.78 | | 0.81 | |

thickness of step. The slopes of the D-T curves (not shown) are similar and not so steep as the slopes of the curves for comparable exposures at 25 or 30 kv. The I.Vs. from the D-T curves are, in enamel 1.41 and 1.34 mm. Al in dentine, 0.84 and 0.83 mm. Al for the 2 and 1½ second exposures respectively; values in satisfactory agreement.

In Table II (paper I), the D.Rs. for the various steps of the penetrometers are given in the films at 51 kv., 30 inches, 30 ma., 2½, 2, 1½, and ¼ seconds' exposure. The longest exposure (2 seconds) gives a film of marked overexposure, the shortest exposure (¼ second) a film of marked underexposure. By plotting the densitometer readings in the various steps against the appropriate thickness of Al, smooth, logarithmic curves are obtained transposed upward in irregular increments of ordinates in order of the length of exposure (Fig. 16). It is easily noted that the slopes of these curves are less steep than those at 41 kv. and still less than those at 30 and 25 kv. (see III E). The I.Vs. in the enamel are 1.45, 1.38, 1.32, 1.40, 1.20, 1.41 mm. Al; in the dentine are 0.84, 0.82, 0.82, 0.83, 0.83 mm. Al for the 2, 2½, 1, ½, and ¼ second exposures, respectively. The variability in the I.Vs. for enamel is

TABLE XXVII

30 KV., 30 INCHES, 30 MA., NO FILTER

| DENSITOMETER READINGS | | 33E4 | 33E5 | 33E6 | 33E7 | 33E8 | 33E9 |
|---|---|---|---|---|---|---|---|
| *Penetrometer* | 10 seconds | 6 seconds | 5 seconds | 4 seconds | 3 seconds | 2 seconds | 1 second |
| FILM *Right* | *Left* | | | | | | |
| EXPOSURE | | | | | | | |
| Step 1 | 2.47–2.47 2.47–2.47 | 1.77 | 1.53 | 1.31 | 1.18 | 0.64 | 0.37 |
| 2 | 1.83–1.78 1.76–1.75 | 1.28 | 1.07 | 0.91 | 0.77 | 0.43 | 0.29 |
| 3 | 1.35–1.33 1.32–1.33 | 0.93 | 0.76 | 0.66 | 0.60 | 0.33 | 0.24 |
| 4 | 1.04–1.04 1.02–1.03 | 0.67 | 0.54 | 0.49 | 0.45 | 0.27 | 0.23 |
| 5 | 0.81–0.80 0.79–0.79 | 0.55 | 0.43 | 0.42 | 0.39 | 0.21 | 0.20 |
| 6 | 0.65–0.66 0.65–0.66 | 0.47 | 0.37 | 0.33 | 0.31 | 0.17 | 0.17 |
| 7 | 0.57–0.57 0.56–0.56 | 0.36 | 0.30 | 0.29 | 0.30 | 0.16 = | 0.17 |
| 8 | 0.54–0.54 0.52–0.53 | 0.32 | 0.27 | 0.27 | 0.28 | 0.16 | 0.17 |
| Enamel — | | 0.57 | 0.47 | 0.43 | 0.40 | 0.25 | 0.18 |
| Dentine — | | 0.96 | 0.73 | 0.65 | 0.58 | 0.30 | 0.21 |
| Film — | | 2.63 | 2.40 | 2.07 | 1.92 | 1.14 | 0.71 |
| INTERPOLATED VALUES | | | | | | | |
| Enamel | 0.74 1.35 | 1.23 | 1.20 | 1.22 | 1.22 | 1.05 | 1.25 |
| Dentine | 1.35 0.79 | 0.73 | 0.83 | 0.81 | 0.81 | 0.86 | 1.00 |

TABLE XXVIII

41 KV., 30 INCHES, 30 MA., NO FILTER, BLACK PAPER-WRAPPED

| | 33 E11 | | 33E12 | |
|---|---|---|---|---|
| FILM | | | | |
| EXPOSURE | 2 seconds | | 1½ seconds | |
| DENSITOMETER READINGS | | | | |
| *Penetometer* | *Right* | *Left* | *Right* | *Left* |
| Step 1 | 2.26–2.27 | 2.32–2.32 | 1.92–1.92 | 1.93–1.93 |
| 2 | 1.89–1.90 | 1.94–1.94 | 1.55–1.56 | 1.59–1.60 |
| 3 | 1.60–1.62 | 1.66–1.65 | 1.32–1.33 | 1.35–1.36 |
| 6 | 1.41–1.41 | 1.42–1.42 | 1.14–1.15 | 1.17–1.16 |
| 5 | 1.21–1.25 | 1.26–1.25 | 0.99–0.99 | 1.00–1.01 |
| 6 | 1.07–1.09 | 1.08–1.08 | 0.87–0.89 | 0.89–0.91 |
| 7 | 0.94–0.93 | 0.93–0.95 | 0.73–0.77 | 0.77–0.79 |
| 8 | 0.85–0.88 | 0.87–0.88 | 0.67–0.68 | 0.70–0.69 |
| Enamel | 1.13 | | 0.96 | |
| Dentine | 1.58 | | 1.31 | |
| INTERPOLATED VALUES | | | | |
| Enamel | 1.41 | | 1.34 | |
| Dentine | 0.84 | | 0.83 | |

partly due to the horizontal nature of the D-T curves and partly due to the difficulty of exactly reproducing conditions at 51 kv. Although the I.Vs. in the dentine are in satisfactory agreement, experience demonstrated that the precision shown in the dentine was much more difficult to maintain at 51 kv. than at 30 kv., consequently the method which was finally used in the study of the tooth slab specifies 30 kv.

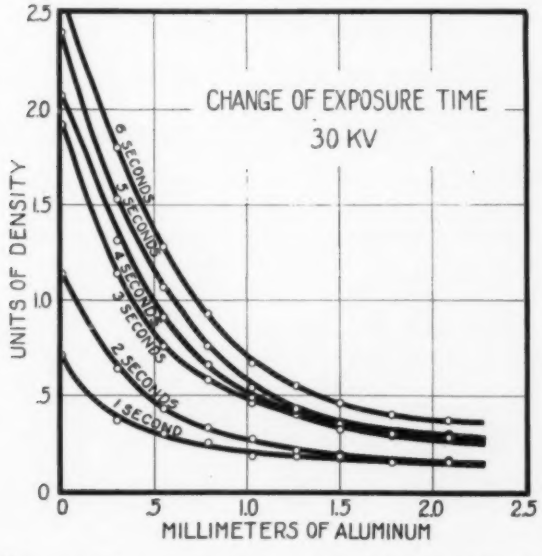



FIG. 15. The D-T curves show fairly regular increments with increasing exposure times. The D-T curve for 1 second exposure is horizontally placed and indicates marked underexposure.

*Conclusion.* By a careful comparison of the data in Tables XXV–XXVIII and Table II (paper 1) it is seen that the variation in exposure time at 20, 25, 30, 41, and 51 kv. gave a series of I.Vs. not differing with

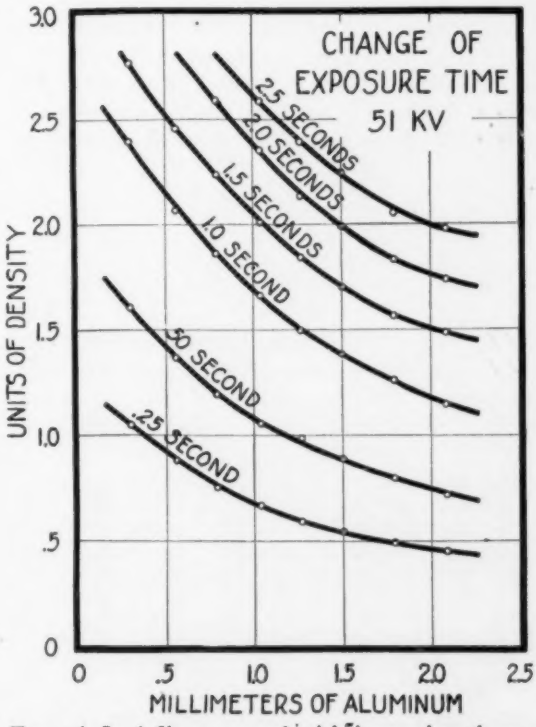



FIG. 16. In 6 films exposed with increasing times to "white" radiation at 51 kv., the D.Rs. are plotted against the proper thicknesses of aluminum.

exposure length, neglecting the exceptional cases already discussed. Thus, when the exposure time is so controlled that the film is neither overexposed or underexposed, the I.Vs. possess satisfactory reproducibility (see section III D, kilovoltage change). A more exact statement of the exposure limits within which contrast between enamel and dentine is correct will be made later.

### D. VARIATION IN TUBE KILOVOLTAGE

In order to test the relation between the I.Vs. for enamel and for dentine and the change of kilovoltage on the tube, a series of exposures are made at 25, 30, 40, 50 and 60 kv., no filter, black paper and exposure times chosen from data given in III c. The peak voltage (sphere gap) measurements were all made in the same way on the same roentgenographic machine so that they are comparable rather than absolute values but suitable for the purpose. The average or effective wave length varies in different machines and especially when mechanical and valve tube rectifiers are compared and also varies with different current loads. From the data presented here it may be seen that increasing kilovoltage produces increasing I.Vs. for enamel but produces no change in the I.Vs. for dentine.

TABLE XXIX

25 KV., 30 INCHES, 20 MA., NO FILTER, BLACK PAPER, 15 SECONDS

| FILM 33E13 | |
|---|---|
| DENSITOMETER READINGS | |
| *Penetrometer* *Left* | *Right* |
| Step 1—2.8 | 2.8 |
| 2—2.29–2.27–2.22 | 2.17–2.15–2.15 |
| 3—1.83–1.79–1.76 | 1.74–1.72–1.72 |
| 4—1.47–1.43–1.42 | 1.42–1.36–1.34 |
| 5—1.23–1.20–1.18 | 1.11–1.10–1.11 |
| 6—1.01–0.95–0.93 | 0.89–0.88–0.91 |
| 7—0.84–0.81–0.78 | 0.75–0.75–0.75 |
| 8—0.71–0.71–0.69 | 0.67–0.62–0.65 |
| Enamel —1.04 | |
| Dentine —1.67 | |
| INTERPOLATED VALUES | |
| Enamel —1.36 | |
| Dentine —0.85 | |

In Table XXIX are recorded the D.Rs. in the various steps of the penetrometers in a film taken at 25 kv., 30 inch distance, 20 ma., no filter, black paper and 15 seconds' exposure. The D-T curve is a typical curve with a slope of about 45° (see III c). The I. V. for the enamel is 1.36 mm. Al, for the dentine 0.85 mm. Al. By comparison with similar I.Vs. from other films at 25 kv. (see III c), the I.Vs. given here are seen to be in satisfactory agreement.

In Table XXX are given the D.Rs. in the various steps of the penetrometers in 4 films taken at 32 kv., 30 inches, 30 ma., no filter, black paper, and 10 seconds' exposure. The D-T curves are similar, logarithmic, sloped about 45°, and in the case of films 32 and 34 coincident for the thinner steps. The I.Vs. for the enamel average 1.36 mm. Al, for the dentine average 0.76 mm. Al. These values are in

TABLE XXX

32 KV., 30 INCHES, 30 MA., NO FILTER, BLACK PAPER, 10 SECONDS

| FILM | 31 | | 32 | | 33 | | 34 | |
|---|---|---|---|---|---|---|---|---|
| DENSITOMETER READINGS | | | | | | | | |
| *Penetrometer* | *Left* | *Right* | *Left* | *Right* | *Left* | *Right* | *Left* | *Right* |
| Step 1 | —2.41–2.41 | 2.38–2.34 | 2.32–2.33 | 2.24–2.24 | 2.15–2.20 | 2.23–2.20 | 2.30–2.28 | 2.27–2.26 |
| 2 | —1.74–1.74 | 1.74–1.69 | 1.67–1.68 | 1.63–1.63 | 1.57–1.58 | 1.59–1.59 | 1.67–1.66 | 1.66–1.65 |
| 3 | —1.33–1.32 | 1.31–1.32 | 1.25–1.27 | 1.25–1.27 | 1.16–1.17 | 1.19–1.19 | 1.23–1.23 | 1.22–1.24 |
| 4 | —1.01–1.03 | 0.99–0.98 | 0.93–0.97 | 0.93–0.97 | 0.88–0.88 | 0.88–0.88 | 0.91–0.91 | 0.91–0.95 |
| 5 | —0.81–0.81 | 0.76–0.77 | 0.71–0.75 | 0.73–0.76 | 0.70–0.70 | 0.70–0.69 | 0.72–0.71 | 0.70–0.75 |
| 6 | —0.65–0.64 | 0.62–0.62 | 0.59–0.61 | 0.59–0.62 | 0.54–0.53 | 0.55–0.56 | 0.53–0.58 | 0.57–0.59 |
| 7 | —0.56–0.54 | 0.53–0.54 | 0.49–0.51 | 0.49–0.52 | 0.48–0.48 | 0.46–0.47 | 0.45–0.46 | 0.47–0.50 |
| 8 | —0.54–0.52 | 0.49–0.51 | 0.45–0.48 | 0.47–0.50 | 0.44–0.44 | 0.44–0.43 | 0.43–0.44 | 0.47–0.49 |
| Enamel | —0.69 | | 0.70 | | 0.61 | | 0.65 | |
| Dentine | —1.37 | | 1.33 | | 1.22 | | 1.28 | |
| INTERPOLATED VALUES | | | | | | | | |
| Enamel | —1.39 | | 1.31 | | 1.40 | | 1.35 | |
| Dentine | —0.76 | | 0.74 | | 0.76 | | 0.77 | |

satisfactory agreement with other I.Vs. at 30 kv.

In Table XXXI are given the D.Rs. in the various steps of the penetrometers in 2 films taken at 41 kv., 30 inches, 30 ma., no filter, black paper and 1½ seconds' exposure. The D-T curves are smooth, logarithmic, crossed in the thicker steps and sloped slightly less than the curves for lesser kilovoltages. The I.Vs. for the enamel are 1.38 and 1.48 mm. Al, for the dentine 0.76 and 0.80 mm. Al for films 35 and 36, respectively; values in satisfactory agreement with other values at 41 kv.

TABLE XXXI

41 KV., 30 INCHES, 30 MA., NO FILTER, BLACK PAPER, 1½ SECONDS

| FILM | 35 | | 36 | |
|---|---|---|---|---|
| DENSITOMETER READINGS | | | | |
| *Penetrometer* | | | | |
| | *Left* | *Right* | *Left* | *Right* |
| Step 1 | 1.58 | 1.53 | 1.42 | 1.45 |
| 2 | 1.23 | 1.22 | 1.14 | 1.12 |
| 3 | 1.01 | 0.97 | 0.92 | 0.91 |
| 4 | 0.82 | 0.81 | 0.78 | 0.77 |
| 5 | 0.70 | 0.64 | 0.67 | 0.62 |
| 6 | 0.60 | 0.55 | 0.53 | 0.55 |
| 7 | 0.47 | 0.47 | 0.47 | 0.46 |
| 8 | 0.43 | 0.41 | 0.43 | 0.44 |
| Enamel | 0.63 | | 0.57 | |
| Dentine | 1.00 | | 0.90 | |
| INTERPOLATED VALUES | | | | |
| Enamel | 1.38 | | 1.48 | |
| Dentine | 0.76 | | 0.80 | |

In Table XXXII are given the D.Rs. in the various steps of the penetrometers in 2 films taken at 51 kv., 30 inches, 30 ma., no filter, black paper and 1 second exposure. The D-T curves are smooth, logarithmic, high in density over the entire range of thickness, crossed in the thicker steps and sloped less than curves at lesser kilovoltages. The I.Vs. for the enamel are 1.45 and 1.42 mm. Al, for the dentine 0.82 and 0.80 mm. Al in films 210 and 220, respectively. These values are in satisfactory agreement with other values at 51 kv.

In Table XXXIII are given the D.Rs. in the various steps of the penetrometers in 2 films taken at 61 kv., 30 inches, 30 ma., no filter, black paper and 0.7 second exposure. The D-T curves are smooth, logarithmic, nearly parallel and sloped less than curves at lesser kilovoltages. The I.Vs. for the enamel are 1.42 and 1.47 mm. Al, for the dentine 0.78 and 0.76 mm. Al in films 37 and 38, respectively.

TABLE XXXII

51 KV., 30 INCHES, 30 MA., NO FILTER, BLACK PAPER, 1 SECOND

| FILM | 210 | | 220 | |
|---|---|---|---|---|
| DENSITOMETER READINGS | | | | |
| *Penetrometer* | | | | |
| | *Left* | *Right* | *Left* | *Right* |
| Step 1 | 2.49 | 2.60 | 2.43 | 2.46 |
| 2 | 2.23 | 2.30 | 2.16 | 2.13 |
| 3 | 2.02 | 2.06 | 1.97 | 1.96 |
| 4 | 1.88 | 1.91 | 1.81 | 1.83 |
| 5 | 1.72 | 1.72 | 1.69 | 1.68 |
| 6 | 1.60 | 1.63 | 1.59 | 1.59 |
| 7 | 1.47 | 1.51 | 1.47 | 1.47 |
| 8 | 1.42 | 1.41 | 1.37 | 1.40 |
| Enamel | 1.63 | | 1.61 | |
| Dentine | 2.00 | | 1.95 | |
| INTERPOLATED VALUES | | | | |
| Enamel | 1.45 | | 1.42 | |
| Dentine | 0.82 | | 0.80 | |

The average I. Vs. for enamel and for dentine are given in Table XXXIV (which includes data from III c). A gradual increase in I.Vs. for enamel and only a negligible change in I. Vs. for dentine occur when the kilovoltage is increased from 20 to 60 kv. In order to illustrate the decrease in slope of the D-T curves with increase in kilovoltage a series of films were made at 30, 40, 50, 60, 70 and 80 kv. (see Fig. 17) with exposure times varied to give approximately equal densities in the film (zero

TABLE XXXIII

61 KV., 30 INCHES, 30 MA., NO FILTER, BLACK PAPER, 0.7 SECONDS

| FILM | 37 | | 38 | |
|---|---|---|---|---|
| DENSITOMETER READINGS | | | | |
| *Penetrometer* | | | | |
| | *Left* | *Right* | *Left* | *Right* |
| Step 1 | 2.20 | 2.21 | 2.10 | 2.06 |
| 1 | 1.98 | 1.99 | 1.90 | 1.91 |
| 3 | 1.83 | 1.85 | 1.74 | 1.73 |
| 4 | 1.72 | 1.71 | 1.66 | 1.64 |
| 5 | 1.61 | 1.61 | 1.54 | 1.56 |
| 6 | 1.47 | 1.49 | 1.49 | 1.45 |
| 7 | 1.39 | 1.37 | 1.40 | 1.35 |
| 8 | 1.33 | 1.31 | 1.31 | 1.29 |
| Enamel | 1.52 | | 1.47 | |
| Dentine | 1.83 | | 1.77 | |
| INTERPOLATED VALUES | | | | |
| Enamel | 1.42 | | 1.47 | |
| Dentine | 0.78 | | 0.76 | |

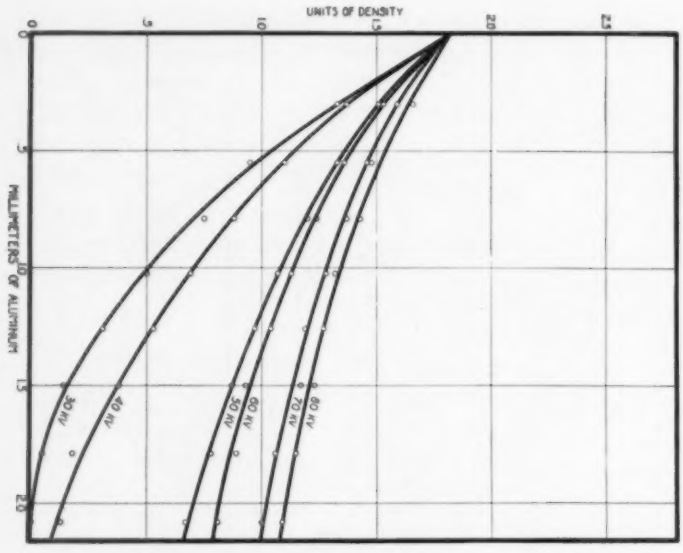



FIG. 17. D-T curves at 30, 40, 50, 60, 70 and 80 kv. from films taken with exposure times adjusted to produce equal densities in those portions exposed to unfiltered radiation (zero thickness Al). Note increasing slopes of D-T curves with decreasing kilovoltage.

thickness of Al). There is apparent (Fig. 17) a pronounced decrease in slope of the D-T curves with increasing kilovoltages. The magnitude of the decrease in slope may be seen by noting the difference between the D.Rs. in Step 1 and Step 8 (Tables XXIX–XXXIII). The difference of densities (Step 1–Step 8) is about 1.3 at 30 kv., 1.2 at 40 kv., 0.8 at 50 kv., 0.7 at 60 kv., 0.6 at 70 kv., and 0.55 at 80 kv.

*Conclusion.* It is evident that the average I.Vs. for enamel tend to increase with kilovoltage increase (see discussion of this later) and that the average I.Vs. in Al for dentine are independent of kilovoltage increase within the precision of the method.

The slope of the D-T curves decreases with increasing kilovoltage.

TABLE XXXIV

| kv. | No. of I.Vs. averaged for both enamel and dentine | Average I.V. enamel | Average I.V. dentine |
|---|---|---|---|
| 20 | 4 | 1.38 | 0.79 |
| 25 | 4 | 1.36 | 0.81 |
| 30 | 17 | 1.32 | 0.79 |
| 40 | 4 | 1.40 | 0.81 |
| 50 | 7 | 1.40 | 0.82 |
| 60 | 2 | 1.45 | 0.77 |

E. VARIATION IN MILLIAMPERAGE

In order to test the independence of I.Vs. for enamel and for dentine from changes in milliamperage, a series of films were taken at constant kilovoltage, distance, etc., and milliamperages of 15, 20, 25, 30, 35, 40 and 50, at exposures of approximately constant milliampere-seconds (also r output). To obtain the range of milliamperage desired, at constant kilovoltage, two autotransformers were connected in series to a single high voltage transformer, thus giving fine gradations of current increase at a definite kilovoltage. The kilovoltages were checked at each milliamperage by the sphere gap method

In Table XXXV are recorded the D.Rs. in the various steps of the penetrometers in 14 films taken with two autotransformers in the machine at 15, 20, 25, 30, 35, 40 and 50 ma., 30 kv., 30 inches, paper-wrapped, and exposures times of 5, $3\frac{3}{4}$, 3, $2\frac{1}{2}$, 2, $1\frac{3}{8}$ and $1\frac{1}{2}$ seconds, re-

TABLE XXXVI

CHANGE MILLIAMPERAGE, I MACHINE, 30 KV., 15 INCHES, PAPER-WRAPPED

| FILM 2139A | 2139B | 2138A | 213 8B |
|---|---|---|---|
| Milliamperes 30 | 30 | 50 | 50 |
| EXPOSURE | | | |
| Time | | | |
| (seconds) 2 | 2 | $1\frac{1}{2}$ | $1\frac{1}{2}$ |
| DENSITOMETER | | | |
| READINGS | | | |
| *Penetrometer* | | | |
| Step 1—2.8 | 2.8 | 1.84 | 1.89 |
| 2—2.76 | 2.67 | 1.49 | 1.54 |
| 3—2.45 | 2.40 | 1.23 | 1.27 |
| 4—2.22 | 2.23 | 1.05 | 1.06 |
| 5—2.00 | 2.03 | 0.89 | 0.90 |
| 6—1.84 | 1.82 | 0.78 | 0.78 |
| 7—1.64 | 1.66 | 0.65 | 0.66 |
| 8—1.51 | 1.55 | 0.56 | 0.58 |
| Enamel —1.94 | 1.87 | 0.84 | 0.80 |
| Dentine —2.45 | 2.34 | 1.26 | 1.30 |
| INTERPOLATED | | | |
| VALUES | | | |
| Enamel —1.34 | 1.40 | 1.35 | 1.46 |
| Dentine —0.79 | 0.89 | 0.78 | 0.76 |

TABLE XXXV

30 KV., 30 INCHES, PAPER-WRAPPED, CHANGE IN MILLIAMPERAGE.

| FILM | 2131A | 2131B | 2132A | 2132B | 2133A | 2133B | 2134A | 2134B | 2135A | 2135A | 2136A | 2136B | 2137A | 2137B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Milliamperes | 15 | 15 | 20 | 20 | 25 | 25 | 30 | 30 | 35 | 35 | 40 | 40 | 50 | 50 |
| EXPOSURE | | | | | | | | | | | | | | |
| Time (seconds) | 5 | 5 | 3¾ | 3¾ | 3 | 3 | 2½ | 2½ | 2 | 2 | 1⅝ | 1⅝ | 1½ | 1½ |
| DENSITOMETER READINGS | | | | | | | | | | | | | | |
| *Penetrometer* | | | | | | | | | | | | | | |
| Step 1 | 2.38 | 2.33 | 2.17 | 2.09 | 2.32 | 2.14 | 1.82 | 1.83 | 2.33 | 1.78 | 2.05 | 1.95 | 2.04 | 2.05 |
| 2 | 1.99 | 1.96 | 1.82 | 1.73 | 1.84 | 1.78 | 1.46 | 1.46 | 2.26 | 1.42 | 1.70 | 1.60 | 1.71 | 1.68 |
| 3 | 1.72 | 1.69 | 1.55 | 1.45 | 1.58 | 1.52 | 1.22 | 1.23 | 1.68 | 1.20 | 1.41 | 1.38 | 1.46 | 1.43 |
| 4 | 1.52 | 1.47 | 1.34 | 1.31 | 1.39 | 1.36 | 1.05 | 1.06 | 1.45 | 1.01 | 1.27 | 1.20 | 1.27 | 1.23 |
| 5 | 1.35 | 1.27 | 1.18 | 1.13 | 1.19 | 1.17 | 0.91 | 0.89 | 1.26 | 0.87 | 1.11 | 1.05 | 1.11 | 1.09 |
| 6 | 1.19 | 1.16 | 1.02 | 1.01 | 1.04 | 1.03 | 0.75 | 0.76 | 1.10 | 0.72 | 0.96 | 0.91 | 0.97 | 0.95 |
| 7 | 1.04 | 0.99 | 0.89 | 0.87 | 0.90 | 0.90 | 0.63 | 0.62 | 0.95 | 0.59 | 0.84 | 0.78 | 0.86 | 0.82 |
| 8 | 0.96 | 0.90 | 0.80 | 0.79 | 0.82 | 0.81 | 0.56 | 0.57 | 0.88 | 0.53 | 0.77 | 0.70 | 0.76 | 0.75 |
| Enamel | 1.23 | 1.21 | 1.08 | 1.04 | 1.11 | 1.07 | 0.82 | 0.81 | 1.18 | 0.78 | 1.00 | 0.95 | 1.05 | 1.04 |
| Dentine | 1.73 | 1.64 | 1.50 | 1.45 | 1.58 | 1.52 | 1.25 | 1.25 | 1.67 | 1.18 | 1.40 | 1.32 | 1.43 | 1.42 |
| INTERPOLATED VALUES | | | | | | | | | | | | | | |
| Enamel | 1.42 | 1.38 | 1.40 | 1.43 | 1.40 | 1.42 | 1.38 | 1.40 | 1.38 | 1.40 | 1.41 | 1.42 | 1.37 | 1.33 |
| Dentine | 0.80 | 0.83 | 0.86 | 0.84 | 0.80 | 0.81 | 0.79 | 0.79 | 0.80 | 0.81 | 0.84 | 0.87 | 0.83 | 0.79 |

spectively. The D-T curves (not shown) are spread, depending for the approximate relative ordinate on the milliampere seconds of a given exposure, are parallel, logarithmic and of less slope than the D-T curves of films at the same kilovoltages on simpler machines (probably due to the kilovoltages being slightly higher for a given reading). There is no apparent dependence in shape or slope of D-T curves on the milliamperage. The average I.V. for the enamel is about 1.4 mm. Al, for the dentine about 0.8 mm. Al. There is no evidence of a dependence of the I.Vs. for either enamel or dentine upon the milliamperage.

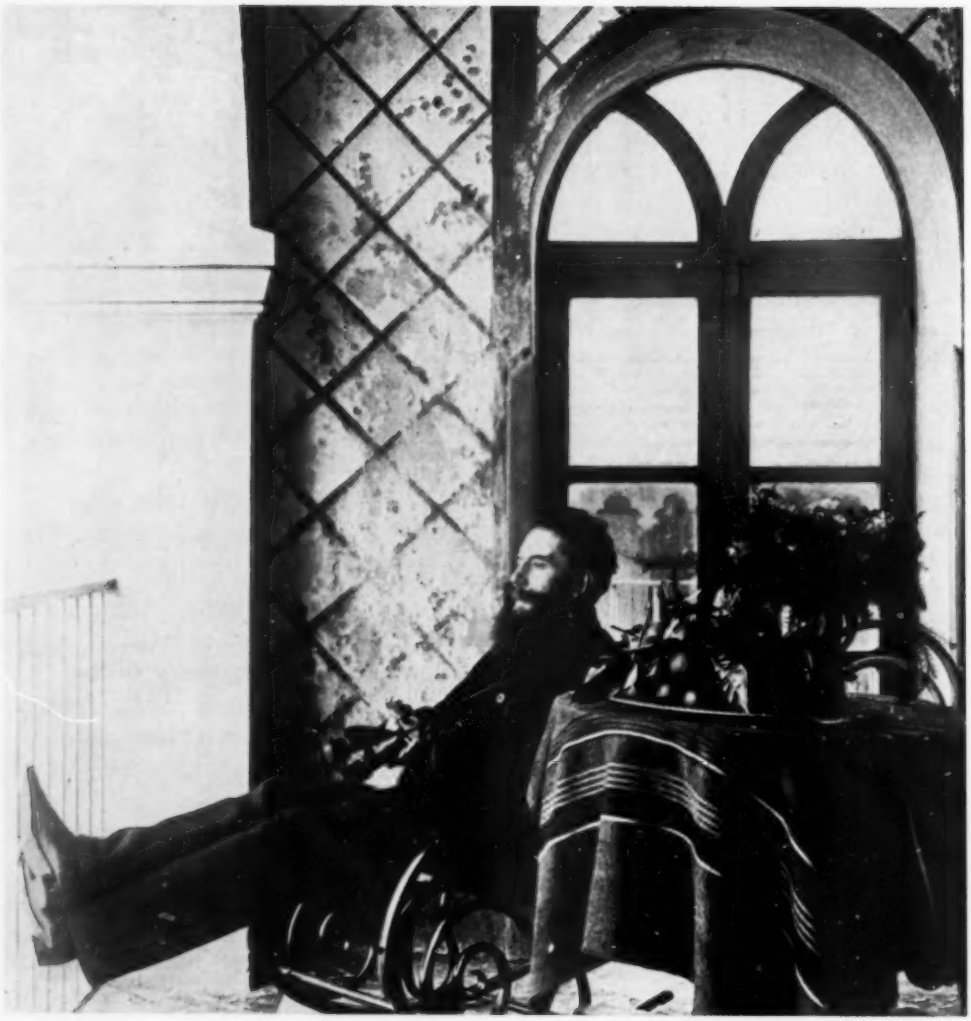
In Table XXXVI are given the D.Rs. in the various steps of the penetrometers in 4 films taken on a single machine at 30 and 50 ma., 30 kv., 15 inches, paper-wrapped, and at 2 and 1½ seconds' exposure, respectively. The D-T curves (not shown) for the films at 30 ma. are high in the density range, crossed, but similar; for the films at 50 ma. are in the usual density ranges, parallel and typical. The average I.V. for the enamel is about 1.4 mm. Al, for the dentine about 0.8 mm. Al.

*Conclusion.* There is no evidence of a relation between the milliamperage and the I.Vs. for either the enamel or the dentine.

## SUMMARY

There is no regular variation introduced in the interpolated values for either dentine or enamel by changes in the intensity or the time of exposure at a constant kilovoltage ($i \times t = C$); or distance if the proper exposure is made; or focal spot size and shape if the proper distance and centering are used. These results are to be expected but it was necessary to verify them experimentally so far as this procedure was concerned.

Increase in kilovoltage (quality of radiation) decreases the slope and changes to a certain extent the position of the D-T curve but does not influence the interpolated value (I.V.) for the dentine. The increase in the I.V. for enamel is due to another factor (difference between the coefficients of absorption of enamel and aluminum) and will be discussed later.



RÖNTGEN, RESTING IN CADENABBIA, ITALY, A FEW WEEKS AFTER THE DISCOVERY OF THE X-RAY

# EDITORIAL

## THE FORTIETH ANNIVERSARY OF THE DISCOVERY OF THE ROENTGEN RAYS

ON THE eighth of November of this year, roentgenologists all over the world will celebrate the fortieth anniversary of the discovery of the x-ray or roentgen ray. Forty years have passed since Wilhelm Conrad Röntgen, Professor of Physics at the University of Würzburg, saw the effect of a strange and unusual phenomenon. He pursued the study of this effect in a most masterly and thorough manner, and discovered it to be due to "a new kind of ray."

Probably the best description of this great discovery was given by Sylvanus P. Thompson, a well-known English physicist, himself an enthusiastic x-ray research worker and president of the newly founded British Roentgen Society, at a meeting held on Friday, November 5, 1897, at St. Martin's Town Hall in London. He said in this address:

> November the eighth, 1895, will ever be memorable in the history of Science. On that day a light which, so far as human observation goes, never was on land or sea, was first observed. The observer, Prof. Wilhelm Conrad Roentgen. The place, the Institute of Physics in the University of Würzburg in Bavaria. What he saw with his own eyes, a faint flickering greenish illumination upon a bit of cardboard, painted over with a fluorescent chemical preparation. Upon the faintly luminous surface a line of dark shadow. All this in a carefully darkened room, from which every known kind of ray had been scrupulously excluded. In that room a Crookes's tube, stimulated internally by sparks from an induction coil, but carefully covered by a shield of black cardboard, impervious to every known kind of light, even the most intense. Yet in the darkness, expressly arranged so as to allow the eye to watch for luminous phenomena, nothing visible until the hitherto unrecognized rays, emanating from the Crookes's tube and penetrating the cardboard shield, fell upon the luminescent screen, thus revealing their existence and making darkness visible.
>
> From seeing the illumination by the invisible rays of a fluorescent screen, and the line of shadow across it, the work of tracing back that shadow to the object which caused it, and of verifying the source of the rays to be the Crookes's tube, was to the practised investigator but the work of a few minutes. The invisible rays—for they were invisible save when they fell upon the chemically painted screen—were found to have a penetrative power hitherto unimagined. They penetrated cardboard, wood, and cloth with ease. They would even go through a thick plank, or a book of 2000 pages, lighting up the screen placed on the other side. But metals such as copper, iron, lead, silver and gold were less penetrable, the densest of them being practically opaque. Strangest of all, while flesh was very transparent, bones were fairly opaque. And so the discoverer, interposing his hand between the source of the rays and his bit of luminescent cardboard, *saw* the bones of his living hand projected in silhouette upon the screen. The great discovery was made.

This report was published in November, 1897, in the second volume of the world's first roentgenological journal, the English *Archives of Skiagraphy*.

There are only a few statements of Röntgen himself preserved which refer directly to the discovery of the x-ray. Two letters, one written by Röntgen to his colleague, L. Zehnder, and the other by Mrs. Röntgen to their cousin, Mrs. Louise Grauel-Röntgen, in Indianapolis, are significant, and on account of their simple language describing the circumstances around the momentous discovery might be called

classics. Zehnder who recently published this letter together with many others in a most interesting book "Röntgen's Letters to Zehnder" received it shortly after the discovery. It reads:

Dear Zehnder. Good friends come last; that's the way it goes. But you are the first to receive an answer. Many thanks for everything you wrote me. I cannot yet make use of your speculations on the nature of the x-rays, since it does not seem permissible or propitious, to attempt to explain a phenomenon of unknown nature with a to me not entirely unobjectionable hypothesis. Of what nature the rays are is altogether not clear to me; and whether they are actually longitudinal light rays is to me of secondary importance. The facts are the important thing. In this respect my work has received recognition from many quarters. Boltzmann, Warburg, Kohlrausch (and last but not least), Lord Kelvin, Stokes, Poincaré and others have expressed to me their joy over the discovery and their appreciation. That is worth a great deal to me and I let the envious chatter in peace; I am not concerned about that.

I had not spoken to anyone about my work; to my wife I mentioned merely that I was doing something of which people, when they found out about it, would say: "Röntgen seems to have gone crazy." On the first of January I mailed the reprints and then hell broke loose! The Vienna Press was the first to blow the trumpet of advertising and the others followed. In a few days I was disgusted with the business; I could not recognize my own work in the reports anymore. For me photography was the means to the end, but they made it the most important thing. Gradually I became accustomed to the uproar, but the storm cost time; for exactly four weeks I was unable to make a single experiment. Other people could work, only I could not. You have no conception how upset things were here.

I am enclosing the promised photographs; if you wish to show them in lectures it is alright with me; but I would suggest that you put them under glass and frame. Otherwise they will be stolen. I think that with the aid of the legends you will have no difficulty with them; if you do, write me.

I use a large Ruhmkorff 50/20 cm. with a Deprez interrupter, and about .20 primary current. My apparatus, which remains on the Raps pump, requires several days for evacuation; the best results are obtained when the spark gap, connected in parallel, is about 3 cm.

How splendidly these words add to the importance of the classical first communication on the x-rays. And how well the following letter of Mrs. Röntgen's illustrates the effect on the Röntgen household of the sudden fame following the first reports on the discovery. The letter was written on March 4, 1896.

Dear Louise. Wilhelm has so much work he doesn't know which way to turn, Yes, dear Louise, it is no small matter to become a famous man, and few people realize how much work and unrest this carries with it . . . When Wilhelm told me in November that he was working on an interesting problem, we had no idea how it would be received, but as soon as the paper was published our domestic peace was gone.

Every day I am astonished at the enormous working capacity of my husband, and that he can keep his thoughts on his work in spite of the thousand little things with which he is annoyed. But now it is high time that he should rest, and I am preparing everything for our departure. We are going south for a few weeks, in order to permit Wilhelm to spend all of his time in the open. Every day I am grateful to God that He made him so healthy and strong, and yet often I am fearful that some day the strain may become too much for him.

But now I talk only of the less lovely part of our experience and have not said a word about our great happiness over the success of his work. Our hearts are full of gratitude that we are permitted to live through such a wonderful experience. How many recognitions has my dear received for his indefatigable research. Often we are almost dizzy with all the praise and honors. It would be alarming if the man who received all this were vain. But you know my honest modest husband as scarcely anyone else does, and you can understand that he finds his highest reward in the fact that he was permitted to accomplish something valuable in serving pure science.

It is very fitting in celebrating the anniversary of the great discovery of the roentgen rays to honor the great man and scientist Wilhelm Conrad Röntgen. His work will live forever.

Otto Glasser

Vol. 34, No. 5

# THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

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*Advisory Committee on Roentgen-ray and Radium Protection:* J. J. Duffy, Chairman, New York City, J. L. Weatherwax, Philadelphia, Pa., W. H. Cameron, New York City.

*Janeway Lecture Committee:* Douglas Quick, Chairman, New York City.

*Committee on Arrangements:* E. H. Skinner, Chairman, Kansas City, Mo., E. K. Robinson, Kansas City, Mo., W. R. Brooksher, Fort Smith, Ark.

*Twenty-first Annual Meeting:* Kansas City, Mo., May 11–12, 1936.

# SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

*Items for this section solicited promptly after the events to which they refer.*

## MEETINGS OF ROENTGEN SOCIETIES*

### UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY
*Secretary*, Dr. F. P. Pendergrass, University Hospital, Philadelphia, Pa. Annual Meeting: Cleveland, Ohio, Sept. 29–Oct. 2, 1936.

AMERICAN COLLEGE OF RADIOLOGY
*Secretary*, Dr. B. H. Orndoff, 2561 N. Clark Street, Chicago, Ill. Annual meeting: Kansas City, Mo., 1936.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
*Secretary*, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: Kansas City, Mo. 1936.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
*Secretary*, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: Detroit, Mich., Dec. 2–6, 1935.

RADIOLOGICAL SECTION, BALTIMORE CITY MEDICAL SOCIETY
*Secretary*, Dr. W. B. Firor, 1100 N. Charles St., Baltimore. Meets third Tuesday each month, September to May.

RADIOLOGICAL SECTION, LOS ANGELES COUNTY MEDICAL SOCIETY
*Secretary*, E. N. Liljedahl, Los Angeles, Calif. Meets on the fourth Wednesday of each month at the California Hospital.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION
*Secretary*, Dr. H. J. Walton, 104 .W Madison St., Baltimore, Md. Annual meeting, St. Louis, Mo., Nov. 19–22, 1935.

BROOKLYN ROENTGEN RAY SOCIETY
*Secretary*, Dr. E. Mendelson, 120 E. 19th St., Brooklyn, N. Y. Meets monthly on first Tuesday, October to April.

BUFFALO RADIOLOGICAL SOCIETY
*Secretary-Treasurer*, Dr. Joseph S. Gian-Franceschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months, place of meeting selected by the host.

CHICAGO ROENTGEN SOCIETY
*Secretary*, Dr. R. G. Willy, 1138 N. Leavitt. Meets second Thursday of each month October to May inclusive at the Palmer House.

CINCINNATI RADIOLOGICAL SOCIETY
*Secretary*, Dr. H. G. Reineke, General Hospital Cincinnati, Ohio. Meets third Monday of each month, October to May, inclusive.

CLEVELAND RADIOLOGICAL SOCIETY
*Secretary*, North W. Shetter, M.D., 14600 Detroit Ave. Meetings are held at 6:30 P.M. at the Cleveland Chamber of Commerce Club rooms on the fourth Monday of each month from October to April, inclusive.

DENVER RADIOLOGICAL CLUB
*Secretary*, Dr. K. D. A. Allen, 452 Metropolitan Building, Denver, Colorado. Meets on any month having a fifth Monday.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY
*Secretary*, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne Country Medical Society Building.

FLORIDA STATE RADIOLOGICAL SOCIETY
*Secretary*, Dr. Gerard Raap, Miami, Florida. Meetings held twice a year, May and November.

ILLINOIS RADIOLOGICAL SOCIETY
*Secretary*, Dr. H. W. Grote, 219 N. Main St., Bloomington, Ill. Regular meetings held quarterly.

INDIANA ROENTGEN SOCIETY
*Secretary*, Dr. J. N. Collins, Indianapolis, Ind. Meeting held the second Sunday in May annually.

LONG ISLAND RADIOLOGICAL SOCIETY
*Secretary*, Dr. M. Dannenberg, 1464 Eastern Parkway, Brooklyn, N. Y. Meets on third Thursday of each month from October to May, at 8:30 P.M.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS
*Secretary*, Dr. S. W. Donaldson, St. Joseph's Mercy Hospital, Ann Arbor, Mich. Three meetings a year, Fall, Winter, and Spring.

MILWAUKEE ROENTGEN RAY SOCIETY
*Secretary*, Dr. S. A. Morton, Columbia Hospital, Milwaukee, Wis. Meets monthly. Place of meeting designed by the president.

MINNESOTA RADIOLOGICAL SOCIETY
*Secretary*, Dr. L. G. Rigler, University Hospital, Minneapolis, Minn.

NEW ENGLAND ROENTGEN RAY SOCIETY
*Secretary*, Dr. Thomas R. Healy, 370 Marlboro St., Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

RADIOLOGICAL SOCIETY OF NEW JERSEY
*Secretary*, Dr. P. S. Avery, New Brunswick, N. J. Meets annually at time and place of State Medical Society. Mid-year meetings at place designated by the president.

NEW YORK ROENTGEN SOCIETY
*Secretary*, Dr. E. F. Merrill, 30 W. 59th St., New York. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

NORTH CAROLINA ROENTGEN RAY SOCIETY
*Secretary*, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY
*Secretary*, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse, N. Y. Three meetings a year—January, May, and November.

PACIFIC ROENTGEN CLUB
*Secretary*, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

PENNSYLVANIA RADIOLOGICAL SOCIETY
*Secretary*, Dr. L. E. Wurster, Williamsport, Pa. Next annual meeting June 5 and 6, 1936, Lycoming Hotel, Williamsport, Pa.

PHILADELPHIA ROENTGEN RAY SOCIETY
*Secretary*, Dr. Thomas Loughery, Germantown Hospital. Meeting first Thursday of each month from October to May inclusive, at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.
*Secretary*, Dr. W. W. Fray, Strong Memorial Hospital. Meets monthly on second Thursday from October to May, inclusive, at 7:45 at the Rochester Medical Association Building.

ST. LOUIS ROENTGEN RAY SOCIETY
*Secretary*, Dr. P. C. Schnoebelen, Missouri Bldg., St. Louis, Mo. Meets first week of each month. Time and place of meetings designated by president.

SOUTH CAROLINA X-RAY SOCIETY
*Secretary*, Dr. R. B. Taft, 105 Rutledge Ave., Charleston. Meets at time and place of South Carolina State Medical Association.

TENNESSEE RADIOLOGICAL SOCIETY
*Secretary*, Dr. F. B. Bogart, 311 Medical Arts Bldg.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
*Secretary-Treasurer*, Dr. J. H. Smith, Lubbock, Texas.
Meets annually one day preceding the meeting of the Texas State Medical Association.

University of Michigan Department of Roentgenology Staff Meeting
*Secretary*, Dr. C. B. Peirce, University Hospital, Ann Arbor, Mich.
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Roentgen Club
*Secretary*, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis.
Meets monthly on last Thursday, October to April, Service Memorial Institute, at 4:30 P.M.

Virginia Roentgen Ray Club
*Secretary*, Dr. V. W. Archer, University Hospital, University, Va.
Meets annually in October.

### Cuba

Sociedad Cubana de Radiologia y Fisioterapia
*Secretary*, Dr. Francisco Padron, Enrique, Villuendas 64, Havana, Cuba. Meets monthly in Havana.

### British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets on the third Thursday of each month, from November to June inclusive, at 8:15 P.M., at 32 Welbeck St., London, W. 1, or as advertised.

Electro-Therapeutic Section of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:30 P.M. at the Royal Society of Medicine, 1 Wimpole St., London, W. 1.

Section of Radiology and Medical Electricity, Australasian Medical Congress
*Secretary*, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
*Secretary*, Dr. Colin Macdonald, Lister House, 61 Collins St., Melbourne, Australia.
Meets monthly at Melbourne during the winter.

Section on Radiology, Canadian Medical Association
*Secretary*, Dr. A. H. Rolph, 160 St. George St., Toronto, Ont.

Radiological Section, New Zealand British Medical Association
*Secretary*, Dr. P. C. Fenwick, The Hospital, Christchurch. Meets annually.

### Continental Europe

Belgian Society of Roentgenology
*Secretary*, Dr. J. Boine, Avenue des Alliés, 134, Louvain (Belgium).
Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summertime.

Société de Radiologie Médicale de France
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean, La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse, Biel.
Meets annually in different cities.

Société Francaise d'Electrothérapie et de Radiologie Médicale.
Meets monthly on fourth Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Association of German Roentgenologists and Radiologists in Czecho-Slovakia
*Secretary*, Dr. Walter Altschul, German University, Prague, II.52.

Deutsche Röntgen-Gesellschaft (Gesellschaft für Röntgenkunde und Strahlenforschung)
Meets annually in April, alternating one year in Berlin, one year in some other German city. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aerzte.
*Permanent secretary*, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

Süd- und Westdeutsche Röntgengesellschaft
Meets annually in different cities.

Nord- und Ostdeutsche Röntgengesellschaft
Meets annually in different cities.

Dutch Society of Electrology and Roentgenology
Holds two meetings a year in Amsterdam, one in the Spring, and one in the Fall.

Societa Italiana Radiologia Medica
*Secretary*, Professor M. Ponzio, University of Turin, Turin.

Societatea Romana de Radiologie si Electrologie
*Secretary*, Dr. Virgil Ionescu, B-dul Schitu Măgureanu 49, Bucarest.
Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
*Secretaries*, Drs. S. A. Reinberg and S. G. Simonson.
Meets annually.

Leningrad Roentgen Ray Society
*Secretaries*, Drs. S. G. Simonson and G. A. Gusterin.
Meets monthly, first Monday at 8 o'clock State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
*Secretaries*, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky.
Meets monthly on the first Monday at 8 o'clock, the place of meeting being selected by the Society.

Polish Society of Radiology
*Secretary*, Dr. Jan. Kochanowski, 45 Gornoslazka St., Warsaw. Meets annually.

Warsaw Section, Polish Society of Radiology
*Secretary*, Dr. B. Krynski, 11 Zielna St.
Meets once a month except in the summertime.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with exception of the Denmark Society, meets every second month except in the summertime.

Society of Medical Radiology in Sweden
Meets in Stockholm.

Society of Medical Radiology in Norway
Meets in Oslo.

Society of Medical Radiology in Denmark
*Secretary*, Dr. G. Biering, Copenhagen.
Meets on the second Wednesday of each month from October to July in Copenhagen, at 8 o'clock in the State Institute of Roentgenology.

Society of Medical Radiology in Finland
Meets in Helsingfors.

Vienna Roentgen Society
Meets first Wednesday of each month, at 6.30 P.M. at Zentral-Röntgen Institut des allgemeinen Krankenhauses Alserstrasse 4.

### Orient

Japan X-Ray Association
c/o Orthopedic Surgery, Tokyo Imperial University.
Meets annually in April.

Kinki Roentgen-Abend Society
Director, Dr. Prof. Taiga Saito, Ogawaoike Tyoto, Japan. Meets bi-monthly on third Sunday.

## OWNERSHIP OF ROENTGENOGRAPHIC NEGATIVES IN MICHIGAN

The following editorial taken from the *Journal of the American Medical Association* will be of interest to roentgenologists as the ownership of roentgenograms is a constantly recurring question and the decision of the Supreme Court, in Michigan, at least, seems to have established definitely the ownership of roentgenographic negatives.

A roentgenographic negative made by a physician as an aid to diagnosis and treatment is, in Michigan, the property of the physician who makes it, unless he has entered into an agreement waiving ownership. The Supreme Court of Michigan rendered this decision September 9,[1] the first rendered by a court of last resort with respect to the ownership of roentgenographic negatives. The decision is binding on all courts in Michigan and it may have persuasive influence on courts in other jurisdictions.

Dr. Burton G. McGarry of Fenton, Mich., on whose initiative this case was brought to a successful issue, had treated an injured employee of the defendant, the J. A. Mercier Company, at its request. The company refused to pay for his services, basing its refusal in part on the ground that Dr. McGarry refused to deliver to the company, for examination by other physicians, certain roentgenographic negatives of the patient, the cost of which was included in Dr. McGarry's bill. At no time did Dr. McGarry refuse to permit other physicians to examine the negatives while they remained in his clinic. In the circuit court judgment was given in Dr. McGarry's favor, and the company appealed to the Supreme Court of Michigan.

Roentgenographic negatives, said the Supreme Court, are practically meaningless to an ordinary layman. They are as much a part of the history of the case as any other record made by a physician. They constitute an important part of a physician's clinical record and preserve much of value in his experience. In a malpractice suit they may constitute unimpeachable evidence that fully justifies the treatment of which a patient complains. They are analogous to the microscopic slides of tissues that physicians make to aid them in diagnosis and treatment and which it would hardly be asserted belong to any one other than the physicians by whom they are prepared. Although roentgenographic negatives differ from the negatives of ordinary photographs, the fact that they are the property of the physicians who make them may possibly be inferred from court decisions that have held that, in the absence of express agreements to the contrary, the negatives of photographs belong to photographers, not to the persons for whom the photographs were made.

There is every good reason, said the Supreme Court, for holding that roentgenographic negatives are the property of the physician rather than of the patient or other person who employs the physician, even though the patient or such other person is charged with the cost of making them. Dr. McGarry was fully justified in refusing to surrender possession of the negatives he had made. In the absence of an agreement to the contrary, such negatives belong to the physician who makes them incident to treating a patient.—*J. Am. M. Ass.*, Oct. 12, 1935.

[1] McGarry v. the J. A. Mercier Co.—Mich.—, —N. W. —.

## RADIUM RESEARCH IN SWEDEN

The battle against cancer in Sweden, which has already been aided by the million dollar jubilee fund subscribed at the time of the King of Sweden's 75th birthday, will now be further stimulated by a donation of 350,000 kroner ($93,800) from a grateful patient at the Swedish Radium Home at Stockholm, the late Mrs. Maria Althainz. The income from the fund will be used for a professorship in radium therapy, the first holder of which will be Dr. Elis Berven, now chief physician at the Radium Home, founded by Dr. Gösta Forsell, the widely known radiologist.

Mrs. Althainz was successfully operated on at the Radium Home for a cancerous growth by Dr. Berven about six years ago. The cause of her death was not cancer.

The holder of the professorship should be free to devote his principal efforts to research, it is stipulated. The estate is to pay the inheritance taxes and the Swedish Government provide a pension. The Radium Home will be moved to new quarters at the Caroline Academy of Medicine in 1937, and there will be two divisions, one for medical radiology and one for radium therapy.—*Am. J. Pub. Health*, Oct., 1935, *25*, 1170.

## AUSTRIAN ROENTGEN SOCIETY

The Austrian Roentgen Society (Österreichischen Röntgen-Gesellschaft) founded in January, 1935, will hold its first Congress in Vienna in February, 1936, the date and place of the meetings to be announced later. One day will be devoted to therapy, another to diagnosis, a third to physics and technique, besides miscellaneous papers and demonstrations in therapy and diagnosis. The entire morning of the first two days will be reserved for guest speakers. Titles of papers and demonstrations must be sent to the President of the Austrian Roentgen Society (Wien IX, Allg. Krankenhaus, Zentralröntgeninstitut) before October 31 and must give a short abstract of the contents.

## EASTERN CONFERENCE OF RADIOLOGISTS

The Eastern Conference of Radiologists will be held in Baltimore, Maryland, on January 31, and February 1, 1936. The headquarters will be the Lord Baltimore Hotel. Further information concerning the Conference may be obtained from Dr. C. A. Waters, 1100 North Charles St., Baltimore, Maryland.

# DEPARTMENT OF TECHNIQUE

*Department Editor:* Robert B. Taft, M.D., M.S., 105 Rutledge Ave., Charleston, S. C.

## A LOCALIZER FOR THE ROENTGENOGRAPHIC EXAMINATION OF THE TEMPORAL BONE IN STENVERS' POSITION

*By* JOHN D. CAMP, M.D.
*Section on Roentgenology, The Mayo Clinic*
*and*
CESARE GIANTURCO, M.D.*
*Fellow in Roentgenology, The Mayo Foundation*
ROCHESTER, MINNESOTA

THE localizer described in this paper is the result of an attempt to devise a simple, practical and accurate method of centering the temporal bone for examination in Stenvers' position. Its development was stimulated by the difficulty frequently encountered in accurately positioning the patient's head for this examination. The localizer is based on the existence of certain fixed and readily distinguishable anatomic landmarks (the external angle of the orbit, the squama temporalis, and the superior attachment of the concha of the ear), and is so shaped that when applied to the head in the manner illustrated (Figs. 1 and 2), the inferior prong of the instrument is parallel to a line passing through the labyrinth of the opposite temporal bone (Fig. 3).

The technique for the use of this localizer is as follows: The cone on the roentgenographic tube stand is centered over

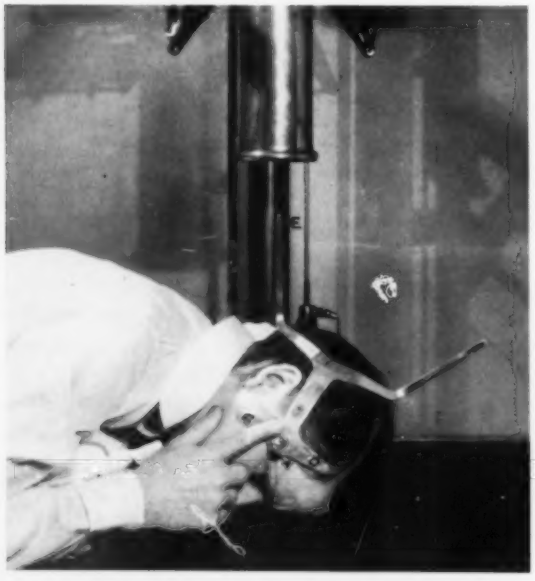

Fig. 1. Lateral view of patient's head properly centered by means of localizer for examination of petrous portion of right temporal bone.

Fig. 2. Vertical view of patient's head properly centered by means of localizer for examination of petrous portion of right temporal bone.

* Now residing at the Carle Hospital Clinic, Urbana, Illinois.

the center of the Potter-Bucky diaphragm. The patient is placed prone on the table with the head beneath the cone. A pillow is used under the patient's chest to make the position more comfortable and to facilitate the tilting of the head. Point *A* (Fig. 1) of the localizer is placed at the external angle of one orbit, and the lower edge of the instrument is placed against the superior attachment of the concha of the ear on the same side. The wings *C* and *D* of the localizer rest against the tissues over the squamous portion of the temporal bone and stabilize the instrument. The head of the patient is now manipulated until the inferior prong *E* of the localizer is parallel with the central roentgen beam. The head is then moved until the temporal bone and mastoid on the side under investigation are in the center of the Potter-Bucky diaphragm, the localizer is now removed and the exposure is made. The procedure is repeated for the opposite mastoid. In many cases when the mastoid is accurately centered the inferior prong of the localizer will be coincident with the central roentgen beam, but this will not always occur since variations in shape of the skull may alter this relation somewhat; however, if the inferior prong of the instrument is always kept parallel to the central roentgen beam and the mastoid is centered as just noted, variations in the shape of the skull will be compensated for.

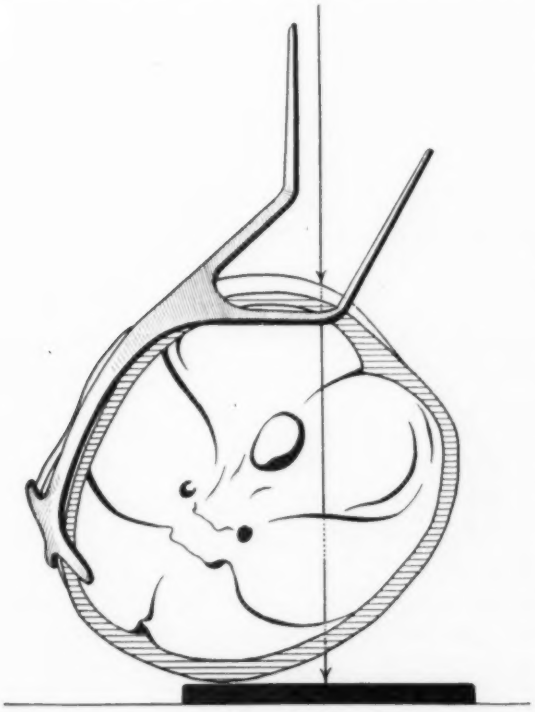

Fig. 3. Localizer applied to skull to show anatomic basis for its use. The inferior prong of the instrument is parallel to a line passing through the labyrinth of the opposite temporal bone.

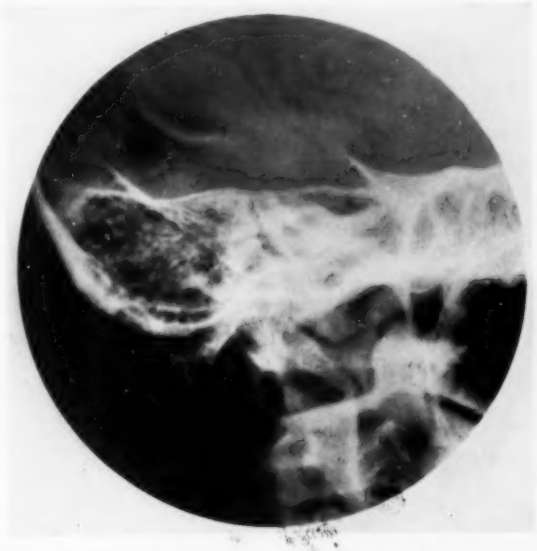

Fig. 4. Roentgenogram of temporal bone in Stenvers' position made by use of localizer.

This position is primarily intended for a study of the petrous portion of the temporal bone, but it also gives an excellent projection of the other portions, especially the tip cells, except that these areas are overexposed when the petrous portion is well-defined (Fig. 4). This disadvantage may be overcome by studying the film in front of a strong light.

REFERENCE

1. Stenvers, H. W. Röntgenologie des Felsenbeines und des bitemporalen Schädelbildes mit besonderer Berücksichtigung ihrer klinischen Bedeutung. Röntgenkunde in Einzeldarstellungen. Julius Springer, Berlin, 1928, 278 pp.

# A NEW ROENTGENOGRAPHIC TABLE

*By* RICHARD A. RENDICH, M.D.
BROOKLYN, NEW YORK

THE roentgenographic table depicted in the accompanying illustrations (Figs. 1 and 2) has been designed to serve the following purposes:

1. To reduce the effort of the technician by having all accessories within reach.

2. To promote neatness of the roentgenographic room and to protect the accessories by furnishing a distinct place for each.

3. To reduce the cost of equipping the roentgen-ray division; the table inclusive of accessories can be furnished for a price less than that of certain special Potter-Bucky tables.

4. To further reduce the possibility of electrical shock through the wood construction.

5. The height of the table being equal to that of the hospital stretcher facilitates the transfer of patients. This increased table height is likewise more convenient for the technician while positioning the patient or adjusting the apparatus.

The angle blocks are arranged to set in a fixed position on the table so that the tube may be readily centered always in the same position; further, the position of the block cannot be changed by movement of the patient's head.

The full length Potter-Bucky travel obviates the moving of the patient when once transferred to the table. The stirrups, readily removable, are useful for pyelography, uterograms, etc., if a special genito-urinary table is not available.

The film storage compartment, lined by one-eighth inch lead, is divided for exposed and non-exposed films and cassettes.

The table has been made to accommodate either the flat or curved diaphragms and without the diaphragm as a plain roentgenographic table.

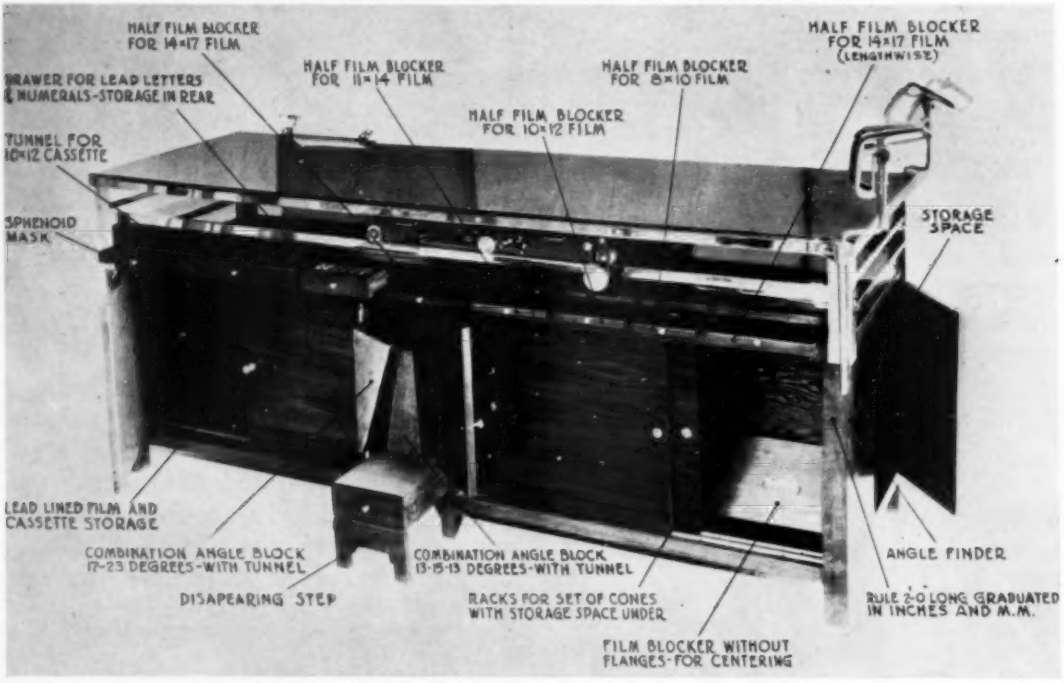
HALF FILM BLOCKER FOR 14×17 FILM
HALF FILM BLOCKER FOR 11×14 FILM
HALF FILM BLOCKER FOR 8×10 FILM
HALF FILM BLOCKER FOR 14×17 FILM (LENGTHWISE)
DRAWER FOR LEAD LETTERS & NUMERALS-STORAGE IN REAR
HALF FILM BLOCKER FOR 10×12 FILM
TUNNEL FOR 10×12 CASSETTE
SPHENOID MASK
STORAGE SPACE
LEAD LINED FILM AND CASSETTE STORAGE
COMBINATION ANGLE BLOCK 17-23 DEGREES-WITH TUNNEL
COMBINATION ANGLE BLOCK 13-15-13 DEGREES-WITH TUNNEL
ANGLE FINDER
DISAPEARING STEP
RACKS FOR SET OF CONES WITH STORAGE SPACE UNDER
RULE 2-0 LONG GRADUATED IN INCHES AND M.M.
FILM BLOCKER WITHOUT FLANGES-FOR CENTERING

FIG. 1

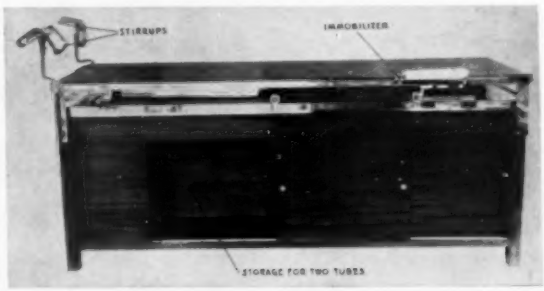


FIG. 2

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# ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

## ROENTGEN DIAGNOSIS

### HEAD

Dale, Torlief. Intracranial calcifications. *Acta radiol.*, 1934, *15*, 628–633.

Intracranial calcifications are seen on roentgenograms quite frequently. Some of them are physiological, such as calcifications of the pineal body, the choroid plexus, the falx cerebri, the attachment of the tentorium and the Pacchionian granulations. Among pathological calcifications calcified tumors are the most important practically. Calcification of a brain tumor is the most important direct sign in an ordinary routine roentgen examination of the skull, but the calcification never gives any definite information in regard to the size of the tumor and rarely in regard to its nature. It is often necessary, therefore, to combine ordinary roentgen examination with ventriculography and possibly with arteriography to determine whether a calcification is caused by tumor and what is its size. The author describes and illustrates with roentgenograms 2 cases of calcified cysts of the hypophyseal duct and 9 cases of glioma verified by operation and 4 probable cases; also 1 case each of angioblastic meningioma, an angioma and an echinococcus cyst. One case of calcified arteriovenous aneurysm diagnosed by arteriogram and cured by operation is described and post-traumatic multiple areas of calcification and calcified tuberculomas are discussed.—*Audrey G. Morgan.*

Lilja, Bengt. On the localization of calcified pineal bodies under normal and pathological conditions. *Acta radiol.*, 1934, *15*, 659–667.

Involution of the pineal body begins in childhood. During this process calcification frequently occurs in the organ to such a degree that it can be recognized by roentgen examination. Differences between a normal and pathological position of the pineal body can only be established by statistical methods. No such statistical investigation has been carried out heretofore. The author therefore studied a series of 200 cases with no roentgen or clinical signs of any expansive intracranial process and determined the normal position of the pineal body and its variability by measurements on roentgenograms. Charts and tables are given showing the details of his results. He also made a similar study of 60 cases of verified brain tumor and found that in a great number of these cases the pineal body was displaced beyond normal limits. Localization of the pineal body is therefore a method of great value in the diagnosis of brain tumors and other expansive intracranial processes.—*Audrey G. Morgan.*

Ebenius, Bertil. The roentgen appearance in four cases of basilar impression. *Acta radiol.*, 1934, *15*, 652–656.

Basilar impression or flattening of the base of the skull is rather rare. It gives a characteristic roentgen picture. The base of the skull around the foramen magnum is thinned and pushed upward. The clivus is deformed and very much less tilted than normal. The floor of the posterior fossa of the skull is generally very thin. In young subjects there are sometimes signs of hydrocephalus which may be primary. Sometimes there are changes in the cervical spine in basilar impression. The atlas may be thinned and defective and may be fused, wholly or in part, with the base of the skull. There may also be deformity of the axis and fusion of the bodies of the vertebrae of the upper cervical region so that the roentgenogram looks like that of Klippel-Feil's syndrome. The head is kept bent slightly backwards giving the patient a characteristic appearance.

Some cases have been attributed to rickets, and thinning of the base of the skull in hydrocephalus is also said to cause depression of the region around the foramen magnum. The symptoms may be those of cerebellar disturbance, symptoms due to compression of the medulla by the odontoid process, signs of irritation and paralysis of the cerebral nerves in the posterior fossa of the skull and of the upper spinal nerves and signs of generalized increase of intracranial pressure.

The course of the disease is generally chronic with slowly progressive symptoms. It may occur in children as well as adults. The only treatment is decompressive trephining and even this is not very effective. Acute compression of the cerebellum may cause sudden death.

The deformity of the posterior fossa of the skull is best seen in lateral and fronto-dorsal projections. In the latter the roentgenograms are taken with the patient in the supine position and the film against the neck, the central ray being parallel with the sagittal plane of the head and the tube inclined 35° cranially from the vertical zero position.

Four cases are described and illustrated with roentgenograms. Two were in children with roentgen signs of hydrocephalus. The others were in individuals forty-six and fifty-nine years of age. There was no senile atrophy or other evident cause of the basilar depression in either of these cases.—*Audrey G. Morgan.*

Wörner, Eduard. Die Bedeutung der Verlagerung der verkalkten Glandula pinealis, insbesondere in Hinsicht auf die röntgenologische Diagnostik der Hirntumoren. (The importance of a displaced calcified pineal gland in the roentgenologic diagnosis of brain tumors.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, May, 1934, *49*, 499–512.

Calcification of the pineal gland has no clinical importance. It occurs in about 50 per cent of persons over twenty years old, more frequently in men. The normal position of the gland has been exactly localized by Vastine and Kinney in calibrated charts and any deviation of the position of the calcified gland may be considered pathologic. Wörner describes 2 cases in which a brain tumor was localized by a study of the displacement of the pineal, following the method of Vastine and Kinney. He also describes a third case in which the pineal shadow was displaced toward an external wound, probably by the contraction of fibrous scar tissue.—*E. T. Leddy.*

Bokelmann, O. Die spezielle Anatomie der Sella turcica und ihre klinische Bedeutung für die Erkennung der Hypophysengrösse, zugleich ein Betrag zur Frage der Beziehungen der Hypophysengrösse sowie Grösse und Form der Sella zum anatomischen und funktionellen Hypogenitalismus. (The special anatomy of the sella turcica and its clinical importance in the recognition of the size of the pituitary and a contribution to the question of the relationship of the size of the pituitary and the size and shape of the sella to anatomic and functional hypogenitalism.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, April, 1934, *49*, 364–396.

Bokelmann shows that (1) there is no direct relationship between the size (capacity) of the sella turcica and the size (weight and volume) of the pituitary. A very small pituitary may be situated in a very small sella, but an enlarged pituitary may be in a medium or even small sella. These facts show that stereoscopic determinations of the size of the sella—at least in physiologic conditions allow only an approximate conclusion about the size of this appendage of the brain. (2) There are direct relationships between the size (weight and volume) of the pituitary and the size of the median plane profile of the sella which under physiologic conditions allow important clinical conclusions to be drawn, as follows: (*a*) A small pituitary fossa in women corresponds to a small pituitary; in men to a small or medium-sized gland. (*b*) A definitely small fossa outline corresponds with a small pituitary in 60 per cent of the cases, possibly to a medium-sized but never to a large pituitary. (*c*) Definitely large fossa profiles correspond with large pituitaries, exceptionally to medium-sized ones, but never to small organs. (*d*) Medium-sized profiles are observed in all enlargements of the pituitary. (3) In advanced age (from fifty-six and upwards) a determination of the median profile of the sella offers uncertain evidence about the size of the pituitary. (4) The size of the lateral profile of the sella cannot be used for determining the size of the pituitary. (5) Estimation of the size of the pituitary by the size of the median profile of the sella is permissible only when the median and lateral profiles of the sella can be differentiated or when both profiles coincide very definitely. An exception is to be made in cases of so-called bridged fossa; in most of these cases there is usually a small pituitary even in those cases where the median profile of the sella is large. (6) A bridging is found surprisingly often (in 50 per cent) in persons who have disturbances of genital function or in whom the sex organs are underdeveloped. (7) In old age the variation in breadth of the pituitary increases with reference to weight and volume. (8) The average weight of the pituitary in women of all ages is higher than in men. (9) During the period of sexual activity there occur in about 50 per cent of females and in about 50 to 60 per cent of males who show a pituitary weight below normal signs of a disturbance of function or underdevelopment of the genitals. —*E. T. Leddy.*

Lindblom, Knut. Bone-free radiography of the eye; a new projection and a film holder. *Acta radiol.*, 1934, *15*, 615–619.

The author describes and illustrates a film holder for bone-free roentgenography of the eye and a new caudocranial projection for the same purpose to supplement the projections that have been used heretofore. A bone-free examination in two planes with localization ought always to be made in cases in which a foreign body is suspected in the eye and the result of transcranial examination has been negative.—*Audrey G. Morgan.*

Rodin, Frank H., and Newell, Robert R. Movements of the eyes under cover: a roentgenographic study. *Arch. Ophth.*, Oct., 1934, *12*, 525–535.

With a special roentgenological technique the movements of the eyes under cover were investigated. The procedure and findings are presented in detail.—*W. R. Brooksher.*

Zuppinger, A., and Rüedi, L. Zur Darstellung des Sinus maxillaris, des Epipharynx und der Trachea mit Kontrastmittel. (The visualization of the maxillary sinus, the epipharynx and the trachea by contrast media.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Feb., 1934, *49*, 176–190.

The maxillary sinus is best visualized by injection of lipiodol after puncture of the sinus through the nose. This examination gives much information about the condition of the mucous membrane in inflammatory diseases and about the involvement of the sinus in neoplastic diseases. The examination is indicated in all obscure conditions in the upper jaw, in tumors of the hard palate, the alveolar process, the nasal accessory sinuses and even in those conditions where the maxillary sinus itself is not primarily in question. The epipharynx is easily visualized when the contrast medium is injected with the patient's head hanging. The method gives evidence as to whether there is narrowing of any of the normal spaces and with a high degree of accuracy as to whether a lesion is benign or malignant. The method is indicated when clinical examination is inconclusive about the extent of a tumor. It alone presents objectively any condition which encroaches on the epipharynx and may give definite indications for the treatment to be adopted. The trachea can be visualized by contrast media if the exposure is made immediately after the lipiodol is injected into the larynx. It gives information about the course of the trachea and the condition of its mucosa. The method is especially indicated when the usual methods of roentgen examination or bronchoscopy are not conclusive.—*E. T. Leddy.*

Kjellberg, Sven Roland. Einige Studien über das Aussehen des weichen Gaumens an Röntgenbildern, teils bei normalen und teils bei einigen pathologischen Zuständen. (Appearance of the soft palate in roentgenograms of normal and pathological cases.) *Acta radiol.*, 1934, *15*, 677–682.

The author describes the normal roentgen appearance of the soft palate and points out that it may swell and become very thick in inflammations in the pharynx. It may also be enlarged in hypertrophy of the lymphoid pharyngeal ring. On the contrary, under some pathological conditions it may be considerably decreased in size. The author has seen this atrophy of the soft palate in cases of extensive tuberculosis.—*Audrey G. Morgan.*

Moore, Austin T. Cystic adamantinoma of the lower jaw. *South. M. J.*, Nov., 1934, *27*, 928–933.

Cystic adamantinoma develops from rest cells of the enamel organ and is epithelial in origin. Enameloblastic cells not used up in the formation of the enamel of a tooth are left deep in the alveolar process and it is from these that the tumors develop. Grossly the tumors appear to be an expansion of the bone and usually affect the lower jaw near the angle. If the maxilla is involved, extension may take place to the antrum. Females are more commonly affected. Usually the only symptom is that of the enlargement. The roentgen ray shows the characteristic findings of multiple cysts centrally placed in the jaw, enlarging at the expense of the cortex. Giant cell tumor may be confused with the lesion. The course is benign, metastasis rarely occurring, and when it does take place, is more probably due to an implantation of cells in the soft tissues from incomplete removal rather than a true metastasis. Treatment should be radical excision. Frequent curettements and partial removal predispose to malignant changes and metastasis. Three cases are presented.—*W. R. Brooksher.*

Fava, Cesare. Una simplice technica per la radiografia dei canali ottici. (A simple technique for roentgenography of the otic canals.) *Arch. di radiol.*, 1934, *10*, 364–369.

Most of the methods proposed heretofore for demonstrating the otic canals have required the use of expensive special apparatus, but the method described by the author is simple and requires no apparatus at all.

In order to get a perfect picture of the otic canals the axis of the canal must be perfectly normal with reference to the plane of the plate. This axis must be traversed by a bundle of rays. The author could not find any two points on the skull such that a line joining them would coincide with the otic canal but he found two such points that define a line absolutely parallel to the otic canal. They are the external occipital protuberance and the apex of the mastoid. A line joining these two points is parallel to the otic canal on that side and therefore if this line is normal with reference to the plate the otic canal is also. He found that this parallelism existed in all forms of skulls and even in skulls that were slightly asymmetrical.

On prolonging the axis of the otic canal backward a point is found on the inner wall of the skull which corresponds externally to the Busi-Balli point of the side opposite to the one on which the canal is being examined. Centering the tube on this point the central ray will pass approximately along the axis of the otic canal.

The patient is placed on the table in a prone position with his forehead on the antidiffusor plane as for a sagittal projection of the skull. After having identified and marked the occipital protuberance and the tip of the mastoid in some way the line which joins these two points is brought into a normal relation to the plane of the plate. It is only necessary to rotate the head outward a little, toward the side to be examined and a little obliquely forward. The tube, at a distance of a meter, is then centered on the Busi-Balli point and the roentgenogram made. Illustrations are given showing the technique. The otic canal can be seen near the external margin of the orbit free of superpositions.—*Audrey G. Morgan.*

Lysholm, Erik. About axial projections of the cranial vertex. *Acta radiol.*, 1934, *15*, 683.

The author describes and illustrates a new projection to demonstrate bone and vascular changes in the midele parasagittal region. The patient's head is placed with the right side against the film on the table so that the central ray forms a tangent with the vertex of the skull when the tube is directly above the center of the table. The tube is then tilted 30° caudad, causing the central ray to make a tangent with the part of the skull nearest the tube. The upper part of the film is placed within the radius of this ray. This results in an "unfolding" of the sagittal suture and the adjacent parts of the skull nearest the film. By placing the left side against the film a corresponding view of the opposite side is obtained.—*Audrey G. Morgan.*

### NECK AND CHEST

Anspach, William E. Atelectasis and bronchiectasis in children; a study of fifty cases presenting a triangular shadow at the base of the lung. *Am. J. Dis. Child.*, May, 1934, *47*, 1011–1050.

*Author's Summary.* An atelectatic bronchiectatic process of the lower lobe has been studied through correlation of necropsy, roentgenologic and clinical studies, throughout life in some cases, and from infancy to puberty in others. Conclusions are based on 50 cases, 20 of which are reported and illustrated.

At the onset, there are frequently symptoms and signs simulating a short siege of pneumonia (collapse) followed by slight fever or even subnormal temperature and frequently by a nonproductive cough for weeks. Later, the cough becomes productive, especially noticeable on awakening. Acute exacerbations of fever may be associated with secondary involvement of adjacent tissue. In the absence of drainage of the bronchi, sooner or later dilatations are formed within the triangular density. Ultimately the clinical and roentgenologic picture of bronchiectasis, as noted in older subjects, makes its appearance.

*Conclusions.* 1. The small well-defined triangular shadow with associated displacement of surrounding structures toward it, frequently noted at the base of the lung in roentgenograms of children, represents a lower lobe in various degrees of collapse. This has been shown by necropsy studies, injections of iodized poppyseed oil 40 per cent, and roentgen observation over long periods. Fluid in the mediastinum and in the mediastinal portion of the pleural space displaces adjacent structures away from the lobe, and, as a rule, a well-defined triangular shadow is not seen in the roentgenogram.

2. While anomalous lobes are frequently seen at necropsy, persistent consolidation or collapse of a supernumerary lobe in the region of the cardiohepatic angle is exceedingly rare. The smallest shadows in the cases here reported were found to represent a regular lower lobe.

3. Necropsies of infants in whom the triangular shadow was present during life did not show dilated bronchi, but in children who continued to live, changes in the triangular shadow appeared later, and bronchiectasis developed.

4. If air entered the collapsed lobe early, the triangular shadow fluctuated in size and was larger and less dense in proportion to the amount of inflation. If postural drainage was instituted early, these fluctuating triangular densities, even though present for years, did not always bring about bronchial dilatations. The triangular shadow is not "pathognomonic of bronchiectasis."

5. If the triangular shadow fails to fluctuate, bronchial dilatations may develop within a few months, but frequently the process covers a period of years.

6. These triangular patterns, when outlined by opaque oils, are frequently seen in adults with bronchiectasis and appear to be acquired rather than congenital.

7. The prognosis can be more accurately determined by observing the behavior of these shadows at successive roentgen examinations.

8. Atelectasis precedes and plays a prominent and most constant rôle in the development of a common form of bronchiectasis of the lower lobe.

9. The most common form of bronchiectasis in children is an acquired process.

10. Early and frequent drainage of the bronchi is essential if the development of bronchiectasis is to be avoided.—*R. S. Bromer.*

Blanton, J. L., and Morgan, G. V. Acute massive collapse complicating pneumonia in an infant five weeks old. *Am. J. Dis. Child.*, May, 1934, *47*, 1070–1079.

The patient, a female infant, was delivered following a normal pregnancy and labor. At three weeks she contracted influenza and two days later developed pneumonia in the right lower lobe. Three days after the onset of the pneumonia she suddenly became much worse, showing on physical examination an absence of breath sounds and dullness over the area of the right lung. The cardiac impulse was displaced to the right of the sternum. After this acute attack she recovered rapidly but severe spells of coughing persisted for three weeks. For six weeks after the onset of the atelectasis she was treated at home, instructions being given the parents to change her position at frequent intervals, to roll her on the unaffected side and to produce crying. Potassium iodide, 0.065 gm. every four hours, was given with the aim of rendering the sputum less viscid. Roentgen examination at the time of the acute attack showed increased density throughout the right lung and displacement of the heart and trachea to the right. Three weeks after the onset, clearing was shown in the right lung from periphery to the hilus. Six weeks after the acute attack, very satisfactory clearing of the right lung was shown and the heart had returned to an almost normal position.

Sudden onset with cyanosis, rapid breathing, rapid pulse and moderate temperature are the usual symptoms of acute atelectasis. This patient had also coughing which occurred in paroxysms similar to the paroxysm of pertussis in infancy. Repeated coughing and cyanosis were relieved by emesis of thick tenacious sputum. Between these attacks the patient was relatively comfortable, three or four attacks occurring every day during the first two weeks. The physical signs and roentgen findings were the usual characteristic type.

From the fact that the atelectasis in this patient occurred after the pneumonic process had apparently begun to resolve, the authors consider that the bronchial secretions played an important part in the etiology. Acute massive atelectasis following pneumonia appears to be a rare complication.

Acute massive collapse occurring in infancy can be differentiated from congenital atelectasis by the fact that the latter is present from birth, by the usual bilateral occurrence of the congenital type and by the fact that it is found chiefly in the central and posterior portions of the lung. Persistence of the cone-shaped thorax of the fetus is also one of the characteristic features of the congenital form of atelectasis, and displacement of the heart and trachea does not seem to occur. Crying sometimes overcomes the cyanosis in the congenital cases whereas in the acute type, the cyanosis is increased by exertion. Crying, however, aids in the latter in re-expanding the collapsed lung.—*R. S. Bromer.*

Taylor, A., and Zweifel, C. Partielle Lungenatelektase als postoperative Komplikation. (Partial atelectasis of the lung as a postoperative complication.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Feb., 1934, *49*, 157–161.

The authors report 2 cases of partial collapse of the lung with displacement of the mediastinum and discuss the differential diagnosis of this condition from other postoperative pulmonary complications. They are of the opinion that the displacement of the thoracic contents seen in pneumonia is due to atelectasis occuring at the same time.—*E. T. Leddy.*

Ellinger, Erika. Parafinölschädigung der Lunge. (Paraffin oil damages of the lungs.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, April, 1934, *49*, 397–403.

Three cases are described of more or less extensive indurative pneumonic infiltration of the lower lobes of the lung as the result of instillation during a long period of large quantities of liquid paraffin. The roentgenogram is not characteristic and differs very little from that of other indurative or pneumonic processes in the lower lobes. Definite diagnosis can be made only with the help of the history. The author suggests that in treatment of diseases of the nose or pharynx the use of paraffin oils be minimized and that they be replaced by saponifiable (vegetable) oils.—*E. T. Leddy.*

Reid, Ada Chree. Tuberculosis case-finding; five years' experience with fluoroscopy. *Am. J. M. Sc.*, Aug., 1934, *188*, 178–184.

The best means of detecting pulmonary tuberculosis is by the use of stereoscopic roentgen films. Where a large number of supposedly healthy individuals are to be examined this method is not feasible because of the expense involved.

Physical examination, history and tuberculin reaction are inadequate in case finding in such a group of adult people.

Since 1927 fluoroscopic examination of the chest has been a part of the complete physical examinations at the home office of the Metropolitan Life Insurance Company. The advantages of this procedure are economy, simplicity of technique, rapidity and accuracy. In the author's opinion fluoroscopy of the chest is approximately as accurate as the single flat film. In 1,035 supposedly healthy individuals examined both by roentgenoscopy and roentgenography, only 2 cases of tuberculosis of clinical significance were missed by the fluoroscopic observation.

The incidence of tuberculosis, as discovered by fluoroscopy, in unsuspected cases has been 1 per cent. This finding has reduced the number of new cases of pulmonary tuberculosis developing in the first year of employment from 92 per 10,000 in 1928 to 43 per 10,000 in 1932. In addition to this the lesions are now discovered earlier in their development. In 1928, 47 per cent of all cases of tuberculosis discovered in employees, had minimal lesions. In 1932, 76 per cent of the lesions found were classed as minimal.

Careful fluoroscopy is recommended as a part of the complete physical examination of large numbers of supposedly healthy individuals.—*G. W. Chamberlin.*

Møller, P. Flemming. On silicosis in porcelain workers from the roentgenological and some clinical points of view. *Acta radiol.*, 1934, *15*, 587–602.

During 1932 and 1933 the Directorate for the Inspection of Factories and Workshops made a study of the occurrence of silicosis in the dust-producing industries in Denmark. Silicosis can be positively demonstrated only by roentgen examination; therefore, roentgen examinations were made of 798 of the total of 859 workers employed in the five porcelain works of the country. Of these 461 were men and 337 women. Some of the others were rejected because they had been working in the industry less than three years and some refused to have roentgen examinations made. Some degree of silicosis was found in 45.2 per cent of the workers. Roentgenograms of cases in various stages are given. Tuberculosis, which is generally spoken of as a frequent complication of silicosis, was rare. Among the 361 workers with silicosis only 43 had demonstrable tuberculosis of the hilus glands in the form of calcification, while only 6 had fresh tuberculosis. Among the 467 without silicosis 65 had gland tuberculosis and 3 fresh tuberculosis. These patients with silicosis are in a precarious condition of health, however, and are constantly threatened with spontaneous pneumothorax and degeneration of the heart. They have a

greater tendency to diseases of the respiratory tract than subjects free of silicosis. In one-half the cases disease of the respiratory tract was the cause of death. Many of the workers complained of dyspnea, coughs and a tendency to colds; emphysema was extremely frequent among the sufferers from silicosis. The silicosis is slowly progressive, of the peribronchial, perivascular, nodular type with a tendency to early interstitial changes. In all of the workers it becomes very severe after the age of fifty.—*Audrey G. Morgan.*

Hawes, John B., 2nd. The effect of acute respiratory tract infections upon latent silicosis. *New England J. M.*, Dec. 20, 1934, *211*, 1147–1148.

Two case reports are presented of individuals exposed to silicon dust for ten to fifteen years some thirty years ago. In the intervening period there had been no known exposure to any dangerous dust nor symptoms of silicosis until after an acute respiratory attack of recent date. In each case this acute illness was followed by characteristic symptoms of silicosis, shortness of breath and cough, and the roentgen ray demonstrated typical findings.—*W. R. Brooksher.*

Belli, Mario. L'indagine radiologica nelle bronchiectasie. (The roentgen picture in bronchiectasis.) *Arch. di radiol.*, 1934, *10*, 321–353.

The author describes and illustrates with roentgenograms 17 cases of bronchiectasis. Ordinary roentgen examination is of less value in the diagnosis of bronchiectasis than clinical examination. The only really effective method is bronchography, that is, roentgen examination after the introduction of 40 per cent lipiodol into the bronchi. The larynx is anesthetized by blocking the superior laryngeal nerve in the hypopharynx with a local anesthetic. A less concentrated anesthetic solution is injected into the bronchi to abolish the cough reflex; 30 to 40 c.c. of lipiodol is then introduced into the bronchial tree with a rubber sound, having the patient assume the position that will best distribute it into the region to be examined. By having the patient cough between the first and second roentgenograms it is possible to obtain pictures of the bronchi of the upper lobes.

Ordinary roentgenograms are of no value in retrocardiac bronchiectasis when the dilatations are covered by the heart shadow. The usual picture in the ordinary roentgenogram in bronchiectasis is that of a chronic bronchopneumonia which may therefore be considered an indirect sign of bronchiectasis. Other cases show fibrosis and mediastinal pleurisy. In some cases ordinary roentgen examination shows slender ring-shaped shadows; if these are associated with clinical signs of bronchiectasis a diagnosis may be made without resorting to bronchography. Bronchography is necessary, however, in all doubtful cases and to establish the exact site of a bronchiectasis for purposes of operation.—*Audrey G. Morgan.*

Tucker, Gabriel. Bronchoscopy in pulmonary disease: present status as an aid in diagnosis and treatment. *Ann. Int. Med.*, Oct., 1934, *8*, 444–458.

The value of bronchoscopy in various pulmonary conditions is discussed. The findings will supplement all other methods of examination in pulmonary disease; but for best results, special training and continuous practice by the bronchoscopist, a trained personnel, adequate instrumentarium, and the support and cooperation of the internist, the roentgenologist and the surgeon, are required.—*W. R. Brooksher.*

Tamiya, C., and Nosaki, S. Diagnose und Therapie gestielter Ösophagustumoren. (The diagnosis and treatment of pedunculated esophageal tumors.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, May, 1934, *49*, 481–498.

The authors report a case of pedunculated esophageal tumor—a fibroma. This is the thirteenth case of non-carcinomatous esophageal tumor in the literature which was diagnosed on clinical and roentgenologic grounds and the fifth case where the diagnosis was verified before death. In this case the tumor was removed and one year later the patient was well. The roentgen characteristics of this tumor were: (1) a central lacunar shadow surrounded by a circular shadow, (2) mobility of the lacunar shadow, (3) persistence of persitaltic movements and elasticity of the esophageal walls, (4) fusiform dilatation of the esophagus near the stenosis, and (5) widening of the mediastinal shadow. These the authors discuss in detail. The majority of these lesions are benign (70 per cent) and pedunculated (12 out of 13 cases). A special technique for representing plastically the tumor and its pedicle is described. By means

of the roentgen signs there should be no difficulty in diagnosing these lesions but they should be differentiated from carcinoma, mediastinal tumors, enlarged thyroid, varices, aneurysms, idiopathic dilatation of the esophagus and foreign body in the esophagus.—*E. T. Leddy.*

Strong, Robert A., and Cummins, Harold. Congenital atresia of the esophagus with tracheo-esophageal fistula. *Am. J. Dis. Child.*, June, 1934, *47*, 1299–1309.

The authors review the literature of congenital atresia of the esophagus, and conclude that the total number of cases reported cannot be regarded as an indication of the rarity of the condition. Within their knowledge, 5 cases occurred in New Orleans within five months. Apparently the anomaly is more frequent than the reported cases would indicate.

There is a striking uniformity of symptoms. During the first twenty-four hours of life nothing is noted but as soon as attempts are made to feed the baby, either water or food, the typical signs begin to appear. Usually before the feeding is attempted it may be noticed that there is a flow of frothy saliva from the mouth. The infant swallows once or twice without trouble. With any further attempt at swallowing, the fluid returns in jets alongside of the nipple and through the nostrils. The child is compelled to breath with the mouth, nose and pharynx full of liquid. It suddenly becomes very blue, stops nursing and then struggles to empty its lungs by coughing. At this stage death from drowning may occur, but, according to Brennemann, not until the infant's defense is weakened, as it is in the latter stages. The most plausible explanation of this protection is that a greater part of the fluid may be drained from the trachea into the stomach by way of the tracheo-esophageal fistula. Such a fistula was present in 215 cases reported by Rosenthal and in 40 was definitely absent. In Strong and Cummins' case the fistula was present, having been demonstrated at autopsy. Roentgen examination showed the barium sulphate in the esophagus which was obstructed just below the level of the interclavicular notch with dilatation above this point. It had passed through the fistulous opening between the esophagus and the trachea and into the right lung. The stomach and intestines were markedly distended by air which had passed through the communication which at autopsy was later proved to exist between the trachea and the cardiac end of the stomach.

The authors list the following developmental defects of the esophagus:

A. Involvement of the entire passage
   1. Stenosis
   2. Atresia, total (reduced throughout to a solid cord)
   3. Agenesia (no detectable vestige of the structure)
   4. Doubling of the whole length of the passage

B. Regional involvements
   1. Stenosis (single or multiple stenotic intervals)
   2. Atresia (either by the narrowing of an interval or by the presence of barrier fold or membrane in an esophagus otherwise normal)
   3. Agenesia (no detectable remnant of a restricted interval)
   4. Fistula communicating with trachea or a primary bronchus
      a. Esophagus otherwise normal
      b. Esophagus divided into upper and lower segments by a regional stenosis, atresia, or agenesia, the fistula being usually single and uniting the lower segment with the trachea
   5. Doubling in a short extent
   6. Diverticula
   7. Cysts

Developmental explanations of the typical esophageal atresia, either with or without fistula, fall into three main classes: (1) It has been suggested that the malformation arises by retention of an assumed normal atresia which is typically transitory. (2) Abnormal deviations of the septum dividing the esophagus and trachea have been postulated. (3) Compression of the tracheo-esophageal structures by blood vessels or by the heart figures as a more recent speculation. The authors agree with Rosenthal that the anomaly is to be explained as a result of a primary deficiency in the developmental capacities of the tissues concerned, and that such mechanical explanations as those which concern deviations of the cleavage of the pulmonary tract from the esophagus do not reach this fundamental seat of disturbance, although they are admittedly of descriptive value. The frequency of other malformations associated with tracheo-esophageal defect should be sufficient reason to question the significance of any agency identified with purely mechanical local disturbances in the growing embryo.—*R. S. Bromer.*

Dehn, O. Über den röntgenologischen Nachweis von pleuralen Adhäsionen. (The roentgenologic demonstration of pleural adhesions.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Jan., 1934, *49*, 93–94.

Dehn states that if no pleural adhesions are present the intrapulmonary shadow moves during expiration in a direction opposite to that taken by the ribs. If adhesion is present the movement is in the same direction. These relationships are best demonstrated by serial exposures during inspiration and expiration.—*E. T. Leddy.*

Kuhlmann, Klas. Zur Ätiologie, Entstehung und Bedeutung der Pleuraverkalkungen bzw. Pleuraverknöcherungen. (The etiology, occurrence and importance of pleural calcification or pleural ossification.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Feb., 1934, *49*, 147–154.

Calcification or ossification of the pleura may follow hemothorax, exudative pleuritis, pleural empyema and tuberculosis. For the production of these conditions it is necessary that a definite supply of lime be available with simultaneous hyperacidity of the tissues, which is usually present when sound and necrotic tissues are in relationship with each other. Further a hemorrhage is necessary, with young connective tissue which may develop in different ways depending on the stimulus. In addition to this there must be a sufficiently large exudate to cause adhesion and later fusion of the adjacent surfaces and the diseased organ must be at rest to a certain extent. If these conditions are present a deposition of lime salts in the tissues may occur—or even true bone formation may take place. The author calls attention to some of the results of these calcifications and describes 3 cases of tuberculous exudative pleurisy and a case of traumatic hemothorax and presents their roentgenograms.—*E. T. Leddy.*

Zdansky, Erich, and Ellinger, Erika. Röntgenkymographische Untersuchungen am Herzen. 2. Mitteilung. (Roentgen kymographic studies of the heart. II.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, March, 1934, *49*, 240–251.

The authors point out the relationships between the changes in the kymographic curves and the changes in volume of the various portions of the heart and the great vessels. A kymogram of the aorta near the arch is described from which the changes in diameter of the aorta can be determined with great precision. The various forces which may produce changes in the kymographic curve of the heart and vessels are discussed. The effect of some of these hemodynamic factors on the kymographic curve of the auricle and ventricles has been analyzed experimentally. A characteristic auricular curve occurring in mitral stenosis is presented. The effect of respiration, forced inspiration and expiration on the kymogram of the right auricle and left ventricle followed through several cardiac cycles are analyzed. These curves show that the size of the heart depends greatly on the stage of filling of its chambers and that it is also greatly influenced by intrathoracic pressure. An analysis of kymographic curves of respiration confirms the view of Laurell, that the so-called respiratory pendulum movement of the heart is produced by the alternating differences of degree of filling of the right and left heart under the influence of the different hemodynamic forces; not only does the degree of filling of the various sections of the heart vary but also the duration of the filling and emptying of the auricle and ventricles. These are variable to a great degree and are to a certain extent independent of the cardiac rhythm and excitation wave of the heart.—*E. T. Leddy.*

Cignolini, Pietro. Die Röntgenkymographie mit unterbrochenem Schlitz. (Roentgen kymography with an interrupted slit.) *Fortschr. a d. Geb. d. Röntgenstrahlen*, March, 1934, *49*, 224–238.

The roentgen kymographic technique with the interrupted slit introduced by the author permits simultaneous study of various sections of the cardiac vessels with definite findings for the different heart periods and an exact analysis of each phenomenon. The apparatus and the tracings obtained by it are illustrated. The author feels that the technique will widen the field of the roentgenologist as a consultant in cardiology, for, as a matter of fact, kymography in many respects is superior to most of the mechanical or electrical methods of examination used by cardiologists. The author feels that a more intense application of the kymogram to the study of cardiac disease will solve many of the difficult problems in this field.—*E. T. Leddy.*

Stumpf, Pleikart. Die kymographische Analyse der Bewegungen des Herzens. (The kymographic analysis of the movements of the heart.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, March, 1934, *49*, 211–224.

Analysis of the movements of the heart by means of the surface kymogram aided by densography is so far developed that the exactness of the polygraphic curves is of first importance in the study of the circulation. In an investigation of a large series of normal hearts the relationship between the movements of the various portions of the heart and those of the aorta has been established. It has been shown that (1) the left ventricle has medial movements only during that part of systole at the beginning of which the greatest relative movement occurs. The greatest difference in amplitude is at the upper and lower parts where the successive periodical displacement is greater than in regions of equal amplitude. (2) In the left auricle four components of movements have been determined, only two of which usually appear definitely. (3) In the right border of the heart three components of movement are present but the effect of these on the various regions is so marked that cranially and caudally quite different in fact contrary movements may be seen. All phenomena of movement in the heart are transitory and periodical so that in nearby fields contraction and expansion may be present. In the first oblique position it can be shown that different movements occur in the anterior and posterior margins, that the widening and change of position anteriorly and laterally are additive, but that any given moment they are subtractive so that the resulting total movement is discontinuous. An important fact is the determination of constant period of contraction during systole with increased pulse rate. The kymograms show no difference in the heart action in the left border with regard to the characteristics of the time and course of the systole but give definite information about partition of the movement the characteristics of which are confirmed by the autopsy and clinical findings. The kymographic study of only a few points of the cardiac contour is generally insufficient for an estimate of the total motion and of the functional relationships. A study of cardiac motion by means of the surface kymogram has two practical applications: (1) the registered movements are a topographical anatomical sign and (2) the movements due to their different partition and variable chronologic course are a functional indication.—*E. T. Leddy.*

Schick, J. L., and Grünberg, A. W. Über die röntgenologische Erforschung des Atmungsmechanismus (Kymographie and Kymorthodiagraphie). (The roentgenologic investigation of the movements of respiration. (Kymography and kymorthodiagraphy.)) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, April, 1934, *49*, 355–363.

The authors studied the respiratory movements of the diaphragm and ribs by the ordinary kymograph utilizing a slit and the electro-orthograph of Charochorkin. In this, registration of the respiratory excursion is made by an electric spark on a moving paper band. The results of the investigation are illustrated, and offer valuable data for finding variations in respiration and in pulmonary capacity.—*E. T. Leddy.*

Freeman, E. B. Chronic pericardial effusion in myxedema: report of case. *Ann. Int. Med.*, March, 1934, *7*, 1070–1079.

The varying opinions on so-called myxedema heart are quoted. Changes in the heart under thyroid treatment are probably due to increased muscle tonus and loss of interstitial edema. The author's case of pericardial effusion occurring in myxedema showed rapid absorption of the effusion when thyroid had been administered in sufficient dosage to bring the metabolic rate up to the accepted low normal. —*W. R. Brooksher.*

Kudisch, B. M. Röntgenologische Studien der Aorta. (Roentgenologic studies of the aorta. II. The roentgenologic symptomatology of aortic disease.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Jan., 1934, *49*, 94–101.

The author describes the appearance of the aorta with typical lesions. On the basis of 1,152 cases he feels that roentgen examination of the aorta gives much important differential diagnostic information.—*E. T. Leddy.*

Ratschow, M., and Arendt, J. Zur Diagnose der Isthmusstenose der Aorta. (The diagnosis of stenosis of the isthmus of the aorta.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, April, 1934, *49*, 347–355.

The clinical findings in stenosis of the aortic isthmus are first discussed by Ratschow and

then Arendt takes up the roentgenologic aspect of this lesion. The sign which is commonest is an increased depth of the costal sulcus. This sign occurs in no other condition; it indicates the formation of a collateral circulation. Unilateral depression of the ribs on the right side favors a stenosis below the left subclavian artery. Enlargement of the left ventricle is no constant sign of aortic stenosis. The most constant roentgen sign is the flattened course of the aorta when viewed in the second oblique position as described by Lewis. The authors feel that by careful combination of the clinical and roentgenologic findings, and especially by observance of changes in the ribs, stenosis of the isthmus of the aorta will be recognized more frequently.—*E. T. Leddy.*

Natvig, Petter. The volume of the heart in Müller's and Valsalva's tests. *Acta radiol.*, 1934, *15*, 657–658.

The volume of the heart increases in Müller's test (inspiration with closed glottis) and decreases in Valsalva's test (forced expiration with closed glottis). The author shows roentgenograms of heart shadows taken during these two tests and describes the method of computing the heart volume from the roentgenogram. In this case the heart volume was found to be 1,050 c.c. in Müller's test and 660 c.c. in Valsalva's test, the difference being 390 c.c. The normal heart volume of the subject is 860 c.c., midway between the two volumes. These tests show the striking elasticity of the normal heart but this method of examination cannot be recommended in cases of suspicious heart disease as it places too great a strain on the heart.—*Audrey G. Morgan.*

Gordon, Wayne, and Adams, Wright. Estimation of cardiac transverse diameter in children and comparison with cardiac area. *Am. J. M. Sc.*, Oct., 1934, *188*, 491–498.

In a group of normal children, consisting of 85 boys and 84 girls, the authors have studied, by means of corrected teleroentgenographic measurements of the heart, the relations of cardiac area and transverse diameter to height, sitting height, weight, and age. In the cases studied they show that both cardiac area and transverse diameter measurements correlate more closely with weight than with height or age. In adults the cardiac area and transverse diameter may be predicted with equal accuracy. In children, however, the standard errors of estimate show greater divergence. The reason for this difference is not entirely evident. It may be due to the fact that the lower border of the heart may be located more easily in children, hence there results a relatively better measurement of cardiac area. In adults it has been shown that the cardiac area method of estimation of heart size separated the normal from the abnormal somewhat better than any method of estimation of the transverse diameter. The authors have not, as yet, applied such a test to their formulas. They feel, however, that as a measure of normal heart size, the advantage of cardiac area over transverse diameter measurements is greater in children than in adults.—*G. W. Chamberlin.*

ABDOMEN

Balaban, I. J. Zur Frage des primären Magensarkoms. (Primary sarcoma of the stomach.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, May, 1934, *49*, 513–518.

This is the description of a large endo- and exo-gastric fibrosarcoma, with regular outlines as seen in the roentgenogram. The round shape, the smooth and sharp contour of the stomach in the author's opinion favored the diagnosis of the lesion not being carcinoma.—*E. T. Leddy.*

Frik, Karl, and Ott, Paul. Tumoren des Magen-Darmtraktus, welche sich im Röntgenbild umschrieben-begrenzt darstellten, und die Schwierigkeiten bei ihrer differentialdiagnostischen Bilddeutung. (Tumors of the gastrointestinal tract which are circumscribed in the roentgenogram and the difficulties of their differential diagnosis.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, May, 1934, *49*, 441–456.

The authors select from a material of 1,300 gastrointestinal cases about a dozen which presented interesting problems of differential diagnosis of well-circumscribed shadows. The lesions in this interesting group were polyps, myomas, granulomas and circumscribed carcinomas. It was impossible to diagnose them from the roentgen findings alone. Mobile polyps may be distinguished from other conditions because they can be moved, and because they may have definite characteristics in the roentgenogram. In many cases the exact diagnosis in this group of lesions can be made only by the pathologic anatomist or surgeon.—*E. T. Leddy.*

Tucker, Gabriel. A method of roentgen localization of foreign bodies in the stomach prior to gastroscopic removal. *J. Am. M. Ass.*, Nov. 10, 1934, *103*, 1440–1441.

A Levin type rubber tube introduced within the stomach facilitates the roentgen localization of the foreign body by reference to the tube prior to the introduction of the gastroscope.—*W. R. Brooksher.*

Ettinger, Alice, and Davis, W. E. X-ray diagnosis of activity and cure of duodenal ulcer. *Am. J. Digest. Dis. & Nutrition*, Oct., 1934, *1*, 579–581.

The advantages of compression technique with the primary aim of demonstrating the actual anatomical changes are detailed. Correlation of clinical and roentgen findings in duodenal ulcer following satisfactory treatment is discussed. Of 83 patients with duodenal ulcer controlled by roentgen examination after treatment, it was found that the niche which had been demonstrated in all cases before treatment had (1) been changed into a scar in 15 cases, (2) decreased in size in 24 cases, and (3) was unchanged in 44 cases. In duodenal ulcer, visualization of the anatomical lesion can be of definite value not only in making the diagnosis, but also in determining the prognosis and method of treatment.—*W. R. Brooksher.*

Blefari-Melazzi, Teofilo. Reporto radiologico di communicazione colecisto-duodenale e colecisto-colica, e calcificazione dell'arteria splenica nello stesso soggetto. (Roentgen demonstration of a communication between the gallbladder and duodenum and the gallbladder and colon, with calcification of the splenic artery in the same patient.) *Radiol. med.*, 1934, *21*, 1136–1146.

Busi was the first to report a case of communication between the gallbladder and duodenum demonstrated by roentgen examination in February, 1917, contemporaneously with the cases of Case and Carman.

The author in this article reports a case in a woman of fifty-six who was sent for roentgen examination because of suspected adhesions between the loops of intestine resulting from a laparotomy some years before. The examination showed a fistula between the gallbladder and duodenum which was verified at operation and one between the gallbladder and colon which was not verified at operation. The operation was not performed, however, until eight months after the examination and a small opening might have closed in that time. The belief that there was an opening between the gallbladder and colon was based on the fact that the colon at the hepatic flexure was tenaciously adherent to the gallbladder and that about twenty minutes after giving the barium meal the colon was filled with contrast while the last loop of ileum, the cecum and ascending colon were not injected. An opaque enema was not given because the contrast medium stagnated in the gallbladder for three days; while the demonstration of a perforation by enema would have been incontrovertible, a negative result would not have disproved it, as fistulas between the various parts of the digestive tube generally permit of passage in one direction and not in the other.

For three days the gallbladder filled with barium did not empty or change its form. This suggested that it had no capacity for contraction, which was confirmed on operation. The lack of any contrast medium in the bile ducts was assumed to be due to occlusion of the cystic duct by calculus or inflammation; this hypothesis was also supported by the fact that no gallbladder bile was obtained on sounding the duodenum. Operation showed the duct obliterated by old inflammation. A calcified vessel with an aneurysm was visible but it was uncertain from its position whether it was the splenic artery or the left renal artery. Intravenous urography with uroselectan B showed that it was not the renal artery. In similar cases the intravenous use of thorotrast would probably be useful, showing the parenchyma of the spleen and clearly demonstrating any vessel entering its hilus.—*Audrey G. Morgan.*

Zanetti, Serse. Colecistopatie e scoliose vertebrali. (Disease of the gallbladder and scoliosis.) *Radiol. med.*, 1934, *21*, 1126–1135.

Deviations of the spinal column have been described in various diseases, particularly appendicitis and kidney disease, but very little attention has been paid to such deviations in gallbladder disease. The author has studied 250 cases, 109 of them controlled by operation. He divides the latter into four groups, 37 cases of biliary calculus, 25 of chronic cholecystitis without stones, 40 of pericholecystitis and 7 of strawberry cholecystitis or lipoidosis of the gallbladder. Among the 37 cases of calculosis there was dextro-convex scoliosis in 24, dextro-

concave scoliosis in 9 and in 4 there was no deviation. Among the 25 cases of cholecystitis without lithiasis there was dextro-convex scoliosis in 17 and sinistro-convex scoliosis in 4; there was no deviation in the other 4. Among the 40 cases of pericholecystitis the spinal column was deviated to the right in 15, to the left in 13 and was straight in 12. Among the cases of lipoidosis the spinal column was straight in 3, slightly deviated to the right in 2 and slightly deviated to the left in 2.

The great preponderance of dextro-convex deviations in cases of cholecystitis is noticeable. Among the two groups 66.13 per cent of the cases showed dextro-convex deviation, 12.90 per cent dextro-concave deviation and 20.97 per cent no deviation. The physiological scoliosis is completely inverted. This is probably brought about by defense contracture of the dorsolumbar muscles. In pericholecystitis, on the other hand, there is only a slight predominance of dextro-convex deviations. Pericholecystitis is often associated with other diseases and the deviation may be due to the primary disease. If this disease is appendicitis the deviation will be sinistro-convex. No conclusions can be drawn in regard to the cases of lipoidosis as the number is too small. Dorso-concave deviation is due to contracture of the psoas and quadratus lumborum. The long and oblique muscles of the back generally do not take part in the process. If they do it indicates a scoliosis of central origin. These cases show that certain forms of scoliosis are muscular in origin.

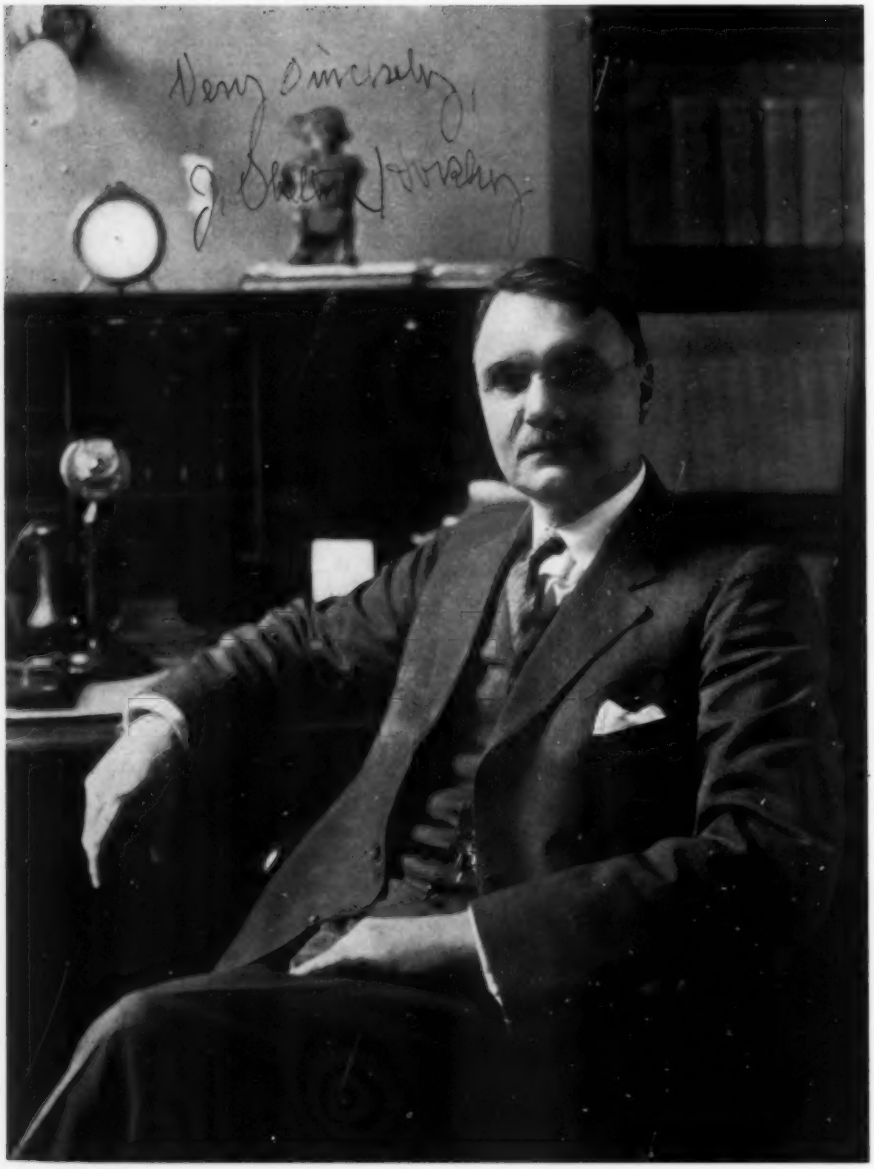
The direction of the curve in scoliosis may be utilized to a certain extent in differential diagnosis. If the history suggests liver disease a dorso-convex curve suggests cholecystitis while if the curve is sinistro-convex it suggests appendicitis.—*Audrey G. Morgan.*

Ivy, A. C., and Sandblom, M. S. Biliary dyskinesia. *Ann. Int. Med.*, August, 1934, *8*, 115–122.

The authors suggest that disorders of motility may constitute a cause of biliary stasis and thus produce gallbladder symptoms in the absence of calculus or inflammation. The historical background of the idea is fully discussed. The present study inquires into the problem from two viewpoints: (1) can the choledocho-duodenal mechanism contract with sufficient force to prevent the gallbladder from emptying under stimulation, and (2) can this effort produce pain in an otherwise normal gallbladder? The authors conclude from their studies on normal humans that pain may be elicited from non-inflamed biliary passages by maximum pressure in their lumina when done quickly where a tonic musculature exists. The common duct sphincter is considered the causal site. The condition may explain the recurrence of symptoms after a cholecystectomy; the basis for gallstone colic without calculi; or the stasis which leads to infection and stone formation.—*W. R. Brooksher.*

Capua, Antonio. Ricerche sul meccanismo di produzione della colecistografia rapida. (Study of the mechanism of production of rapid cholecystography.) *Arch. di. radiol.*, 1934, *10*, 370–376.

Antonucci in 1931 reported his rapid method of cholecystography by the combined administration of glucose and tetraiodid. There is no question of the usefulness of the method but the author tried to determine the mechanism of its production. He proceeded by injecting into dogs choleretic substances for water and salts—that is, substances which stimulate the secretion of the liver and which Brugsch and Horsters define as choleretics as distinguished from cholagogues which stimulate a flow of bile from the gallbladder. He used phenyl-quinolin-carbonic acid and sodium glycocholate. He did not succeed in obtaining rapid cholecystograms within the first three hours. They did appear sooner however than after the injection of tetraiodid alone. He concludes that water and saline choleretics are not the essential factors in bringing about rapid cholecystography; at most they are secondary factors.—*Audrey G. Morgan.*



*Dementi Studio*

J. SHELTON HORSLEY

*Caldwell Lecturer, 1935*